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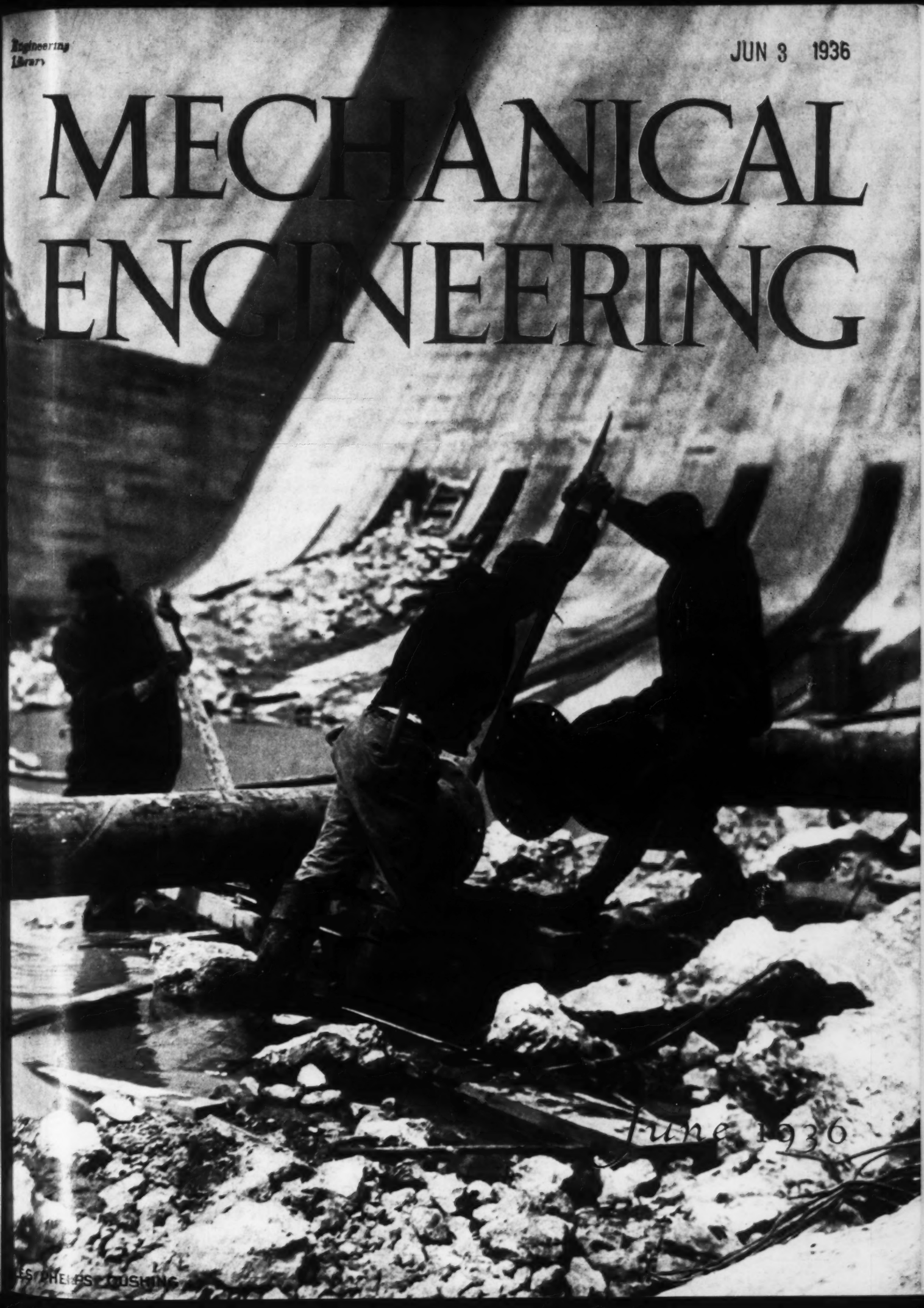

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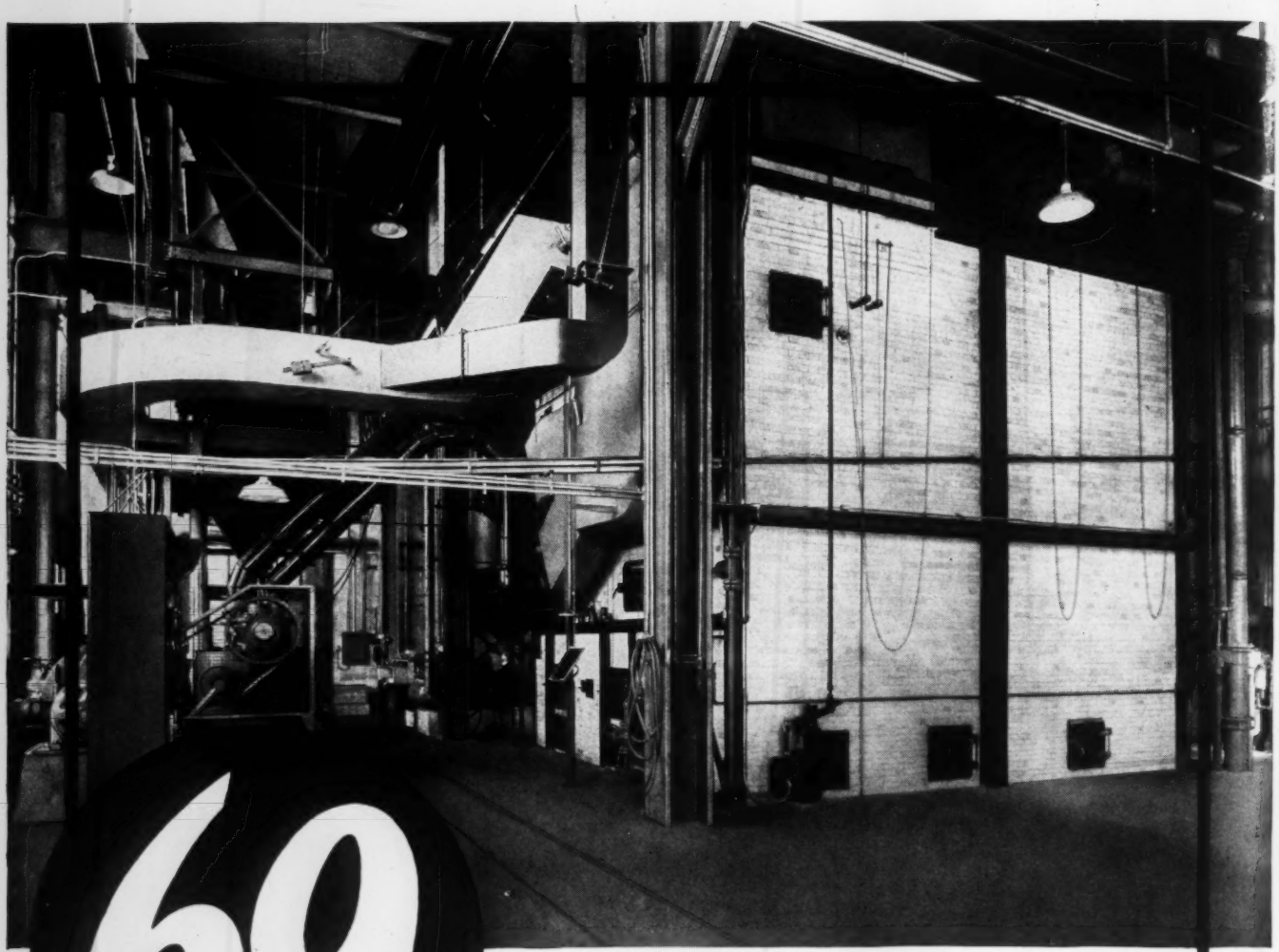

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MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 58 NUMBER 6

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Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B2, Par. 3). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . .Copyrighted, 1936, by The American Society of Mechanical Engineers.Member of the Audit Bureau of Circulations.

Robert Yarnall Richie

Reverse of Glass Mirror for 200-Inch Telescope

(*See pages 345–351*)

VOLUME 58
No. 6

MECHANICAL ENGINEERING

JUNE
1936

GEORGE A. STETSON, *Editor*

A Sound Platform

READERS of MECHANICAL ENGINEERING are familiar with views on economic, social, and industrial problems that Past-President Flanders has expressed over a period of years in addresses and papers devoted to these subjects. They will welcome, therefore, the convenient and well-organized summary of Mr. Flanders' philosophy contained in his recent book, "Platform for America." Here in 118 pages are discussed such subjects as raising the farm standard of living, unemployment, business risk and social safety, recovery, and the challenge of the new frontier. A synthesis of Mr. Flanders' conclusions forms the final chapter—"The Platform," a forthright statement that is in keeping with the progressive spirit and free institutions by which this country grew great, that exhibits a sympathetic awareness of conditions facing society, and the great urge for a higher standard of living coupled with that kind of security that is not purchased at the expense of restricted opportunity for individual initiative. The planks of the platform are devoted to business, agriculture, labor, banking and finance, and government. The "platform" will appeal to a majority of engineers, whose approach to the important problems dealt with will be much the same as Mr. Flanders'.

Papers by Juniors

FROM time to time lately we have been privileged to publish papers by junior members of The American Society of Mechanical Engineers. Another example is presented this month in the article on the use of solar heat for air conditioning homes in Florida.

There were many young men among the early members of the A.S.M.E., men who later advanced to a maturity in engineering practice that made them frequent and notable contributors to the Society's publications. George M. Bond, for example, presented a noteworthy paper within a year after his graduation from Stevens Institute that represented an admirable piece of writing and a thorough study of accurate measurements. He found his life's work in this field and fully justified the splendid promise represented in his early work. He, and many others like him, should serve as an example to the youth of the present generation to work diligently for the rewards that professional practice brings to men and for the satisfactions that come with the publication of their written work.

Although the junior paper published this month may have a somewhat negative conclusion it does show a more than superficial study of a problem in engineering and a willingness on the part of the investigator to look without prejudice at many factors necessary for the success of a proposed scheme. It is a pleasure to publish the serious studies of young men. Should Mr. Green attain distinction as an engineer the Society will have cause to feel gratified at having encouraged his early work.

An End to Isolation

WITH the completion of its first round trip between Germany and the United States, the *von Hindenburg*, largest airship yet constructed, draws serious attention to the shortening of crossings between Europe and America and demonstrates the practicability of aerial travel over great ocean expanses. While several years will probably elapse before travelers will turn naturally to this form of transportation, there will be those whose sense of adventure, of keeping up with progress, or of the value to them of rapid crossings will compel them to patronize any fairly regular service that may be established. Faith in the safety of the airship seems to be unquestioned, although memory of disasters to military ships still haunts skeptics. And not the least of the results of the recent accomplishment will be a revival of public interest in attempts, recommended by a distinguished board of experts in this country, by the United States Navy to continue its support of the airship by building ships for experimental purposes.

The airship's crossing consumed an incredibly short time, the record return voyage having been made from Lakehurst to Frankfort-on-Main in 49 hours. Even shorter crossings, we are told, will be possible, and equally practicable, with the large flying boat. Mr. Sikorsky, at a recent meeting in New York, spoke of a 24-hour service between the two continents as a possibility of the immediate future, utilizing a 50-ton craft in which accommodations for passengers would permit considerable freedom of movement in the commodious fuselage of the huge ship. Where we now take a week's or ten-day's trip to the West Indies in luxury liners, we shall in the future, he promised, be visiting the Mediterranean countries and Egypt on no longer holidays. It is all very exhilarating until the military implications are considered. America is no longer isolated from the rest of the world.

Aerodynamics in Transportation

ALMOST the newest of engineering sciences, aerodynamics is making its contributions to its older companions. Spurred by the higher speeds attained in aerial transport where efficiency in the use of the driving power must be utilized to the limit and suffering from the competition thus offered, the railroads, for several years, have been trying to apply researches in aerodynamics to the streamlining of trains.

Streamlining, as Mr. Sillcox points out in his paper in this issue, has fastened on to the public fancy. What does it mean to the railroads? This is what Mr. Sillcox endeavors to set forth, starting with the formulas and wind-tunnel tests and ending with what may be called the psychological aspects of the problem.

Here we find another example of the interchange of knowledge developed in fields of applied science that seem quite remote at first glance. Wind-tunnel tests of train shapes would hardly have been given serious consideration before the days when wind-tunnel tests of aircraft became such an essential factor in aeronautical design. In the few years that airplane designers have made use of the wind tunnel, the importance of this type of research has grown tremendously and wind-tunnel technique has become an effective working tool.

This recalls to mind that remarkable developments in wind tunnels have greatly increased the range of tests made possible thereby. The pressure tunnel was the first of these important developments and it has now been followed by a wind tunnel in which there is a supersonic velocity of flow. According to information published by the Brown, Boveri & Co. who built an axial blower for the supersonic tunnel of the Swiss Federal Institute of Technology at Zürich, the power required to operate wind tunnels of this kind is very considerable, especially as the mass of the objects tested becomes greater and approaches full-scale size. Professor Ackeret, of the Swiss Institute of Technology, calculates that 25,000 hp would be necessary for a wind velocity of 700 km per hr at atmospheric pressure and a tunnel diameter of 4.5 meters. For outputs of this size motor drives cannot be used and Ackeret suggests driving the wind-tunnel blower by a steam turbine. The very fact that such a high-powered tunnel is seriously mentioned is an indication of the value of the researches that may be conducted by means of it.

The Great Telescope

SINCE the early days of modern science the telescope has been a symbol of scientific advance, of man's groping for greater truth, of his conquest of the darkness of dogma and ignorance. There is something about the phrase "light-gathering power" as applied to the 200-inch telescope described in this issue that has inspiring significance. To recall the days of Copernicus and Galilei, when authoritarianism limited men's outlook and hampered their search for scientific truth, serves to emphasize the contrast between the freedom with which men work and study today and the hazards they faced during the Renaissance. Without intellectual freedom, science and human progress languish.

But we cannot be too sure that we have banished forever those handicaps to scientific advance that the authority of church and state once imposed. Recent nationalistic madness in the countries where great minds once were smothered and persecuted has in it the seeds of restriction to free inquiry that made those days so dark for human understanding. Interference with intellectual freedom may yet serve to recall the dark ages. Hence a telescope of unprecedented light-gathering power may become a reminder of that precious heritage of intellectual freedom in the search for truth as well as a technical triumph in aiding astrophysical research.

Captain McDowell's description of the new 200-inch reflector also emphasizes the high degree of engineering and technological skill that must be exercised in the design and construction of scientific instruments of this high order. It will be recalled by mechanical engineers that several A.S.M.E. past presidents have devoted their talents to the building of telescopes. John Brashear, the steel-mill hand who spent his spare hours grinding lenses for his own telescopes, became the most famous maker of lenses and mirrors of his day. Warner and Swasey, Yankee mechanics who developed a high degree of skill in precision machine work in the manufacture of lathes, transferred that skill to the design and construction of the structural elements of these important instruments. And James Hartness, manufacturer of machine tools, built telescopes for his own use on designs suggested by the basic principle of his flat turret lathe.

MECHANICAL ENGINEERING has noted the accomplishments of the telescope makers from time to time for many years, and it is in keeping with this tradition that it presents this month what is probably the first description of the 200-inch instrument being constructed for the California Institute of Technology.

Women Workers

ONE of those popular myths about labor was quite successfully dissipated in a recent pamphlet by the National Industrial Conference Board entitled, "Women Workers and the Labor Supply." The pamphlet reports a factual study filled with statistics and charts and should serve to eradicate the delusion held by many persons that woman offer serious competition to men in business and industry. It shows, for example, that the great bulk of women workers enter the labor market in the rôle of supplementing, rather than supplanting, the services performed by men. Without women, says the report, we would not have had workers enough; and evidence does not exist to show that, even during the depression, although employment of women fell off less than did that of men, the unemployment of men was increased.

THE 200-INCH TELESCOPE

Some Details of Design of a New Instrument for the Astrophysical Observatory, California Institute of Technology

By CAPT. C. S. McDOWELL, U.S.N.

CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIF.

THE 200-INCH telescope is primarily due to the vision of one man, Dr. George Ellery Hale. He may be described as the world's greatest telescope builder, in that, starting with the 40-inch Yerkes, he progressed to the 60-inch and 100-inch instruments at Mt. Wilson and now to the 200-inch, a sketch of which is shown in Fig. 1.

In an article published in *Harpers Magazine* in 1928, Dr. Hale presented some advantages of large telescopes. The article brought a sympathetic response from Dr. Wickliffe Rose who was at that time president of the International Education Board of the Rockefeller Foundation.

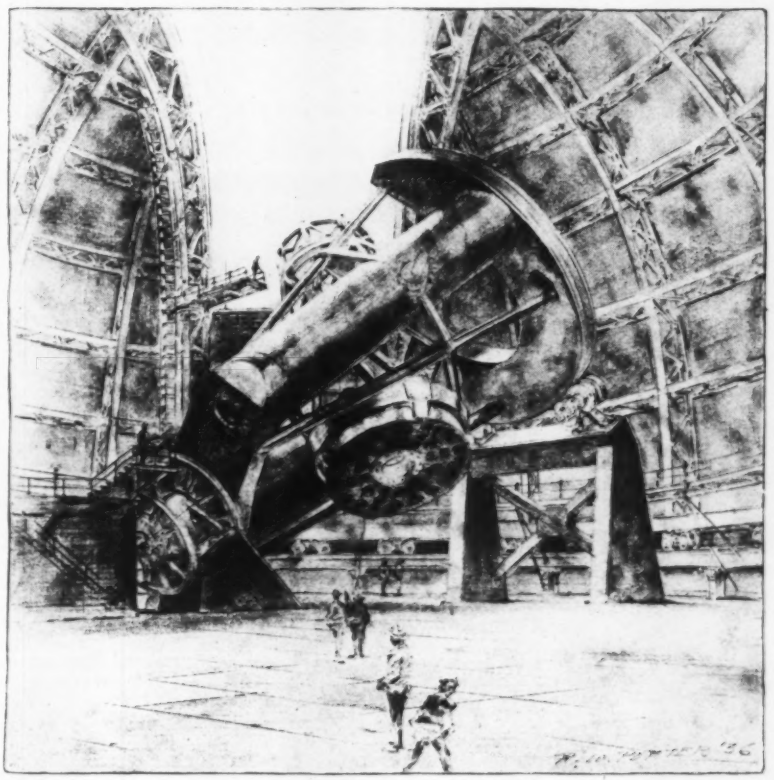


FIG. 1 ARTIST'S SKETCH OF 200-INCH TELESCOPE AND PORTION OF OBSERVATORY THAT WILL HOUSE IT

As the result of ensuing discussions, the International Education Board offered to finance the construction of a 200-inch telescope and observatory to house it which is to become the new Astrophysical Observatory of the California Institute of Technology.

In designing instrumental equipment for the new observatory, the chief points that have been borne in mind are:

(1) To supplement rather than duplicate existing apparatus of the Mt. Wilson Observatory and the California Institute of Technology.

(2) To multiply the efficiency of all instruments, not merely by increase in size but by every possible improvement in method of design and construction, and especially by the development of new auxiliary apparatus.

(3) To render the results of these investigations available at once to other observatories and research laboratories where their immediate utilization might lead to new advances long before the completion of the 200-inch telescope.

Experience at Mt. Wilson has clearly demonstrated that the 200-inch telescope should be an equatorial reflector of large angular aperture, so mounted as to permit observation at the principal or prime focus of the 200-inch mirror, at the Cassegrain focus below the mirror, and at the coudé focus within a constant-temperature laboratory south of the polar axis. Reference to Figs. 2 and 3 will afford an opportunity to study the general arrangement of the telescope and the dome as well as the optical system.

In any discussion, of the design of the 200-inch telescope it should be borne in mind that some of the parts and apparatus are still in a stage of development, and, though at present they present apparently satisfactory solutions to the requirements, they may in the final stage be quite different from what is here presented.

The telescope may be divided into the following major components:

(*a*) The optical system which consists of the 200-inch mirror and auxiliary mirrors, Fig. 3.

(*b*) The telescope tube and mounting with the necessary trunnion bearings and declination axis, and bearings at the south and north ends to permit rotation in right ascension, Figs. 1 and 2.

(*c*) The precision drive and control of position of the telescope.

(*d*) The dome, including foundations and pedestals for the telescope, with a rotating part in which is an opening so

Presented at a meeting of the Los Angeles Section with the Southwestern Student Branch Conference, California Institute of Technology, Pasadena, Calif., April 2, 1936, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

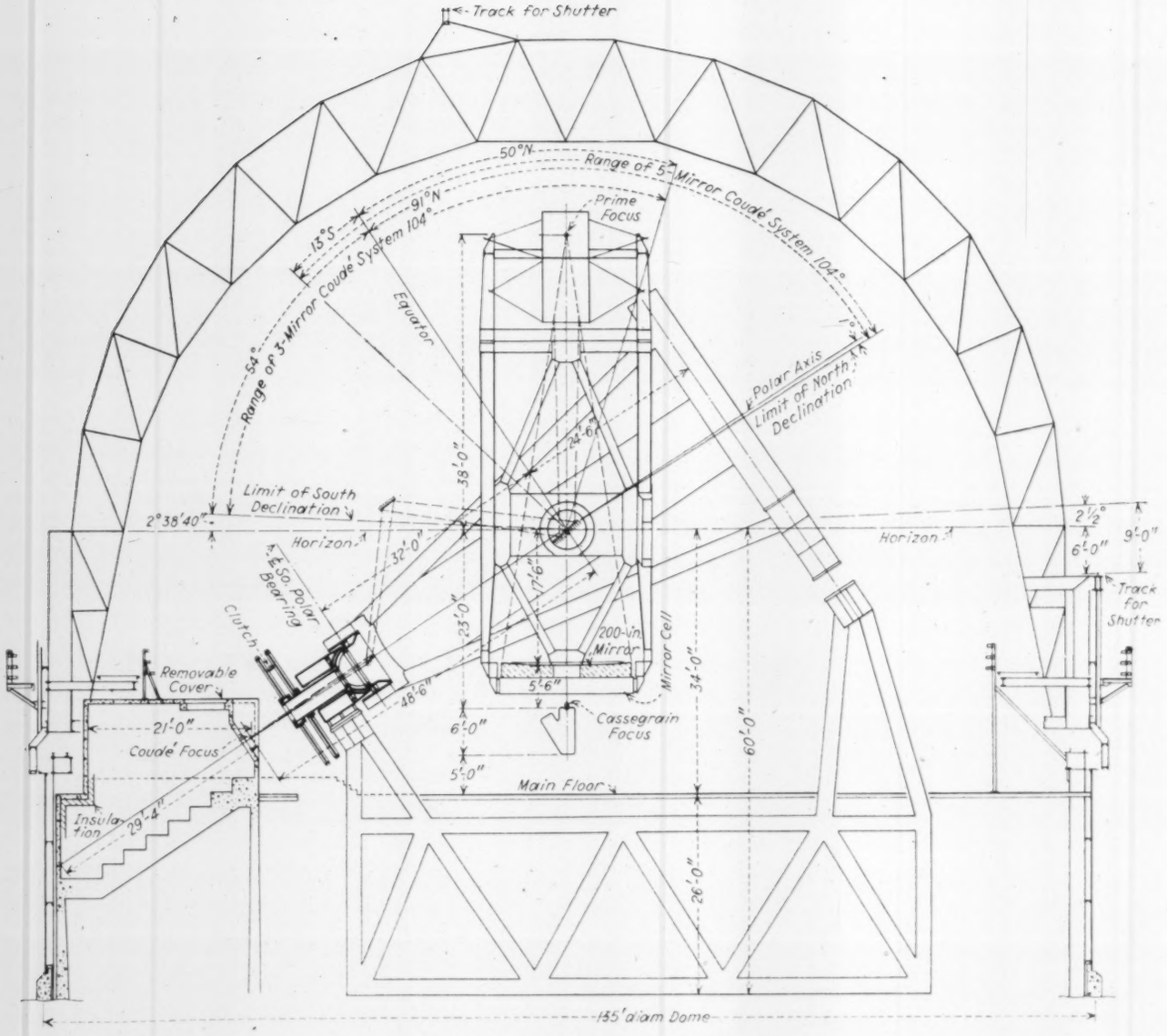


FIG. 2 SECTION OF OBSERVATORY DOME AND 200-INCH TELESCOPE

that the telescope may be pointed through it toward any object in the heavens, Figs. 1 and 2.

It is desired that each of the major parts of this telescope be given equal attention and that the final design be developed so as to coordinate all parts and provide the best complete apparatus that can be built at this time, utilizing to the fullest the best present-day knowledge in the engineering and scientific fields.

In the intervening 20 years since the 100-inch telescope was designed and built many technical improvements have been made in the various fields that are involved in the design of such an instrument. Some of these developments are: Glass having a low coefficient of expansion, such as the superpyrex used for the mirror of the 200-inch telescope, which has a coefficient of 0.0000025 per deg C; electric welding which permits the building of structures that are both strong and light and which is used in fabricating the tube, yoke, and mirror cell; alloys having low coefficients of expansion which make it possible to utilize individual supports for the mirror having the same coefficient of expansion as the glass; accurate remote-control mechanism such as is used in elevators, dock locks and which will be utilized in controlling the movements in right ascension and declination of the telescope; more accurate timing apparatus such as the crystal-controlled or the tuning-fork-controlled electric clocks which will permit a more accurate sidereal clock; and many other general improvements in engineering and technique which will be put to use as well as some interesting technical developments which may be applicable to the new instrument.

Certain astronomical requirements or specifications have been established for this telescope and the engineering design is based on meeting or bettering these requirements. Thus, in the design of the tube and mirror supports, the stiffness requirement is set by the allowable departure of the Ross correctors from the optical axis of the instrument. According to the calculations of Dr. Ross, the correctors must be held within 0.040 in. of the axis and must not change more than 0.020 in. during exposure. Assuming an exposure time of one hour, this leads to an overall tolerance of 0.080 in. of the tube and supports combined in moving from the horizontal to vertical position. The tube has been designed so that the two ends, bearing, respectively, the large mirror at the lower end and the auxiliary

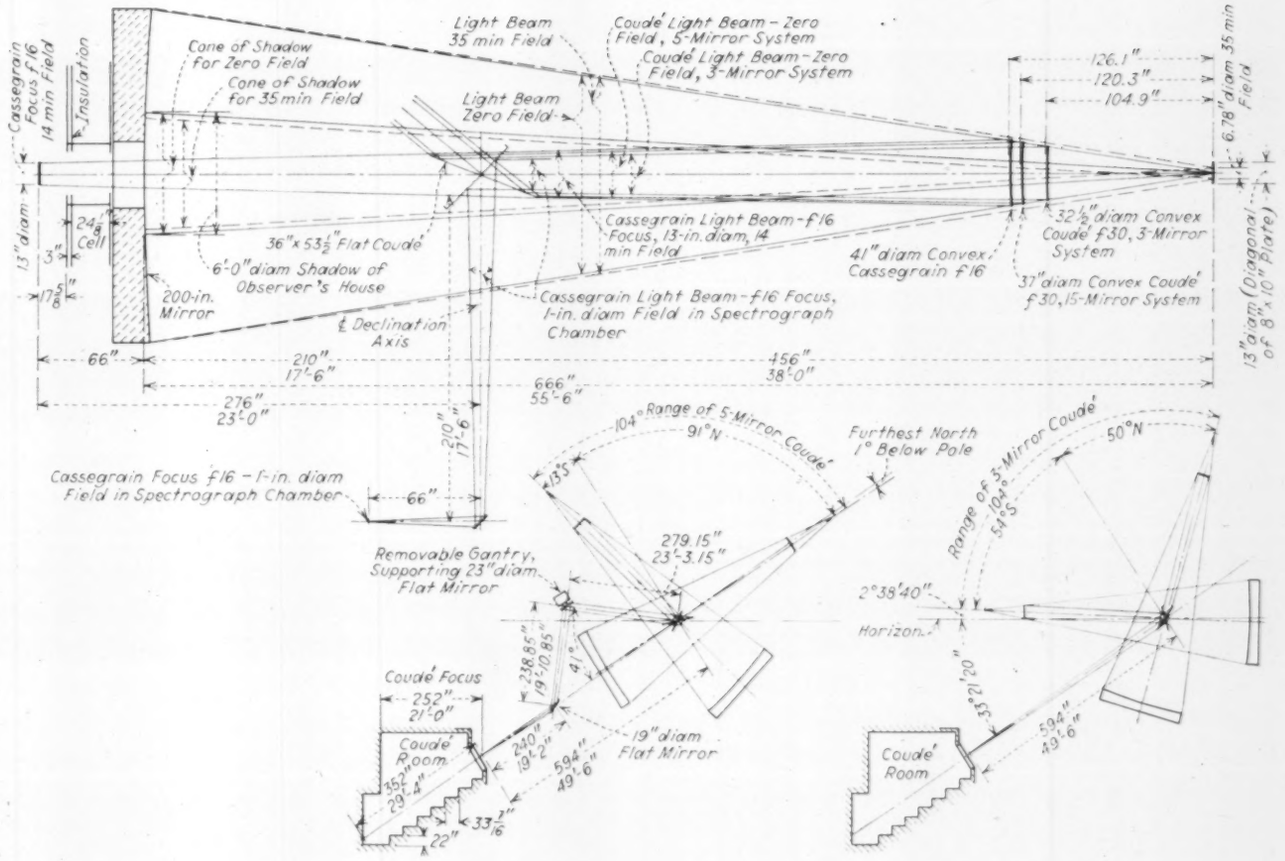


FIG. 3 OPTICAL SYSTEM OF 200-INCH TELESCOPE

mirrors and prime focus at the upper end, while deflecting will remain parallel, and the computed displacement and results from tests of the telescope model show this to be 0.040 in. as compared to an allowable 0.080 in. The change in angle between the ends, where the allowable change is one minute, will be about ten seconds.

The cage, a model of which to a one-tenth scale is shown in Fig. 4, is mounted at the upper end of the tube and carries an enclosure containing the prime-focus optical unit and the auxiliary mirrors for the Cassegrain and coudé foci. The cage may be turned to certain positions and can be removed and replaced by special cages for any special work that future developments may require. The cage also carries an observer's house 72 in. in diameter, supported separately from the prime-focus house in which the observer operates when using the prime focus. This arrangement should prove much superior to the usual Newtonian form in which the light is intercepted by a diagonal mirror and brought out at the side of the tube. It conserves light by avoiding an extra reflection and eliminates a mirror which is especially subject to distortion.

The tube will weigh approximately 250,000 pounds and will be 22 ft square at the center member and 57 ft in length. Fig. 5 shows a model of the tube and cage constructed to a one-tenth scale for test purposes.

The yoke, a model of which to a one-tenth scale is shown in Figs. 6 and 7, has been designed so as to hold the polar axis correct within 3 sec of arc. This means an allowable deflection of $^3/_8$ in. while the computed deflection is $^1/_{16}$ in. The weight of the yoke is 600,000 lb; the length 60 ft 6 in.; the diameter of the horseshoe at the north end is 46 ft. The side members tying the north and south ends together are cylinders 10 ft 6 in. in diameter. Inside of these cylinders spectrographs or other instruments may be mounted and operated from the Cassegrain coudé focus.

The telescope must be able to be pointed to any part of the sky from $2^1/_2$ deg above the south horizon to 1 deg below the pole, and from 105 deg east to 105 deg west, Fig. 2.

BEARINGS

The polar axis of the instrument is the instantaneous axis of rotation of that part of the yoke or mounting which carries the declination bearings. It may change its position in space, but if the instrument is to follow properly, it should remain always parallel with the axis of the earth. The yoke or mounting must furnish mechanical support for the tube and also establish this axis of rotation—polar axis—and furnish uniform rotation about that axis. Supported at the north end of the yoke is the horseshoe which is made in this shape in order that the tube may be turned to 1 deg below the polar axis. The horseshoe must be supported in some manner to permit smooth and uniform motion while at the same time maintaining the accuracy of alignment of the polar axis. We have investigated various methods of supporting this horseshoe. At the present time our designs have crystallized to the use of one of two types of bearings:

(1) Oil pads utilizing the viscous flow of the film of oil and maintaining a clearance of approximately 0.003 in. between the pads and the horseshoe. Calculations and tests show that the torque required to overcome friction of a north bearing of this type would be about 35 ft-lb at the driving speed of the instrument. Unless difficulties arise which are not now foreseen, this will probably be the type of bearing used.

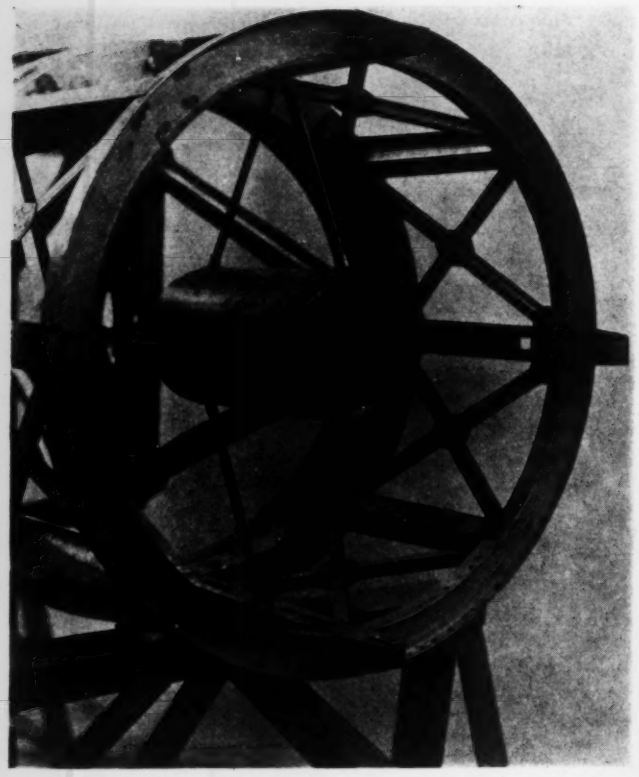


FIG. 4 ONE-TENTH-SCALE MODEL OF 200-INCH TELESCOPE CAGE SHOWING PRIME-FOCUS UNIT

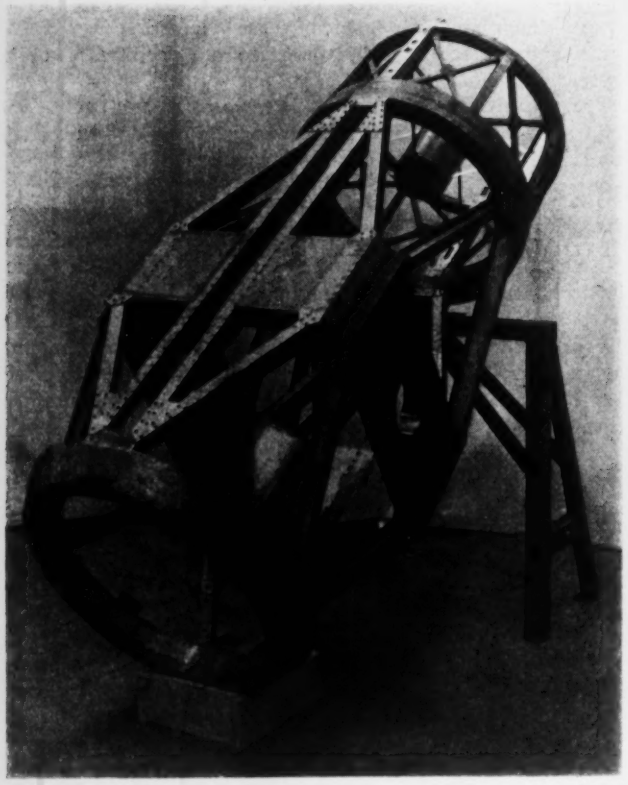


FIG. 5 ONE-TENTH-SCALE MODEL OF 200-INCH TELESCOPE TUBE AND CAGE

(2) Roller bearings have been developed sufficiently to lead us to believe they can be considered as an alternate in case it becomes necessary to change from the oil pads. In the case of the roller bearings, torque required to overcome the friction at the north end will be about 22,000 ft-lb at driving speed.

At the south end we have considered various methods of support, all taking care of the effect of deflections of the yoke on the bearing. Here again the type of oil bearing as shown in

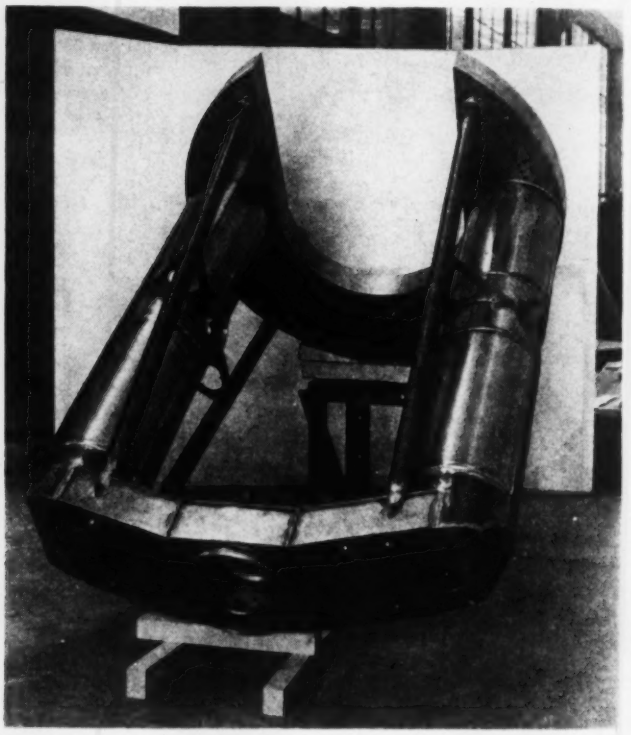


FIG. 6 SOUTH END OF ONE-TENTH-SCALE MODEL OF YOKE FOR 200-INCH TELESCOPE

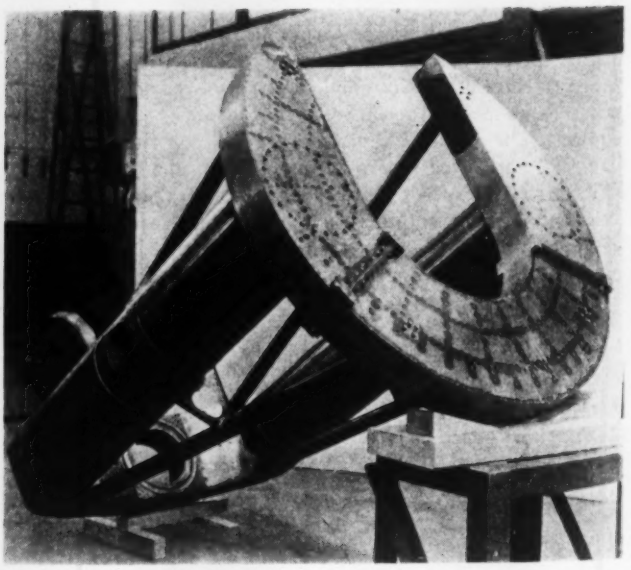


FIG. 7 NORTH (HORSESHOE) END OF ONE-TENTH-SCALE MODEL OF YOKE FOR 200-INCH TELESCOPE

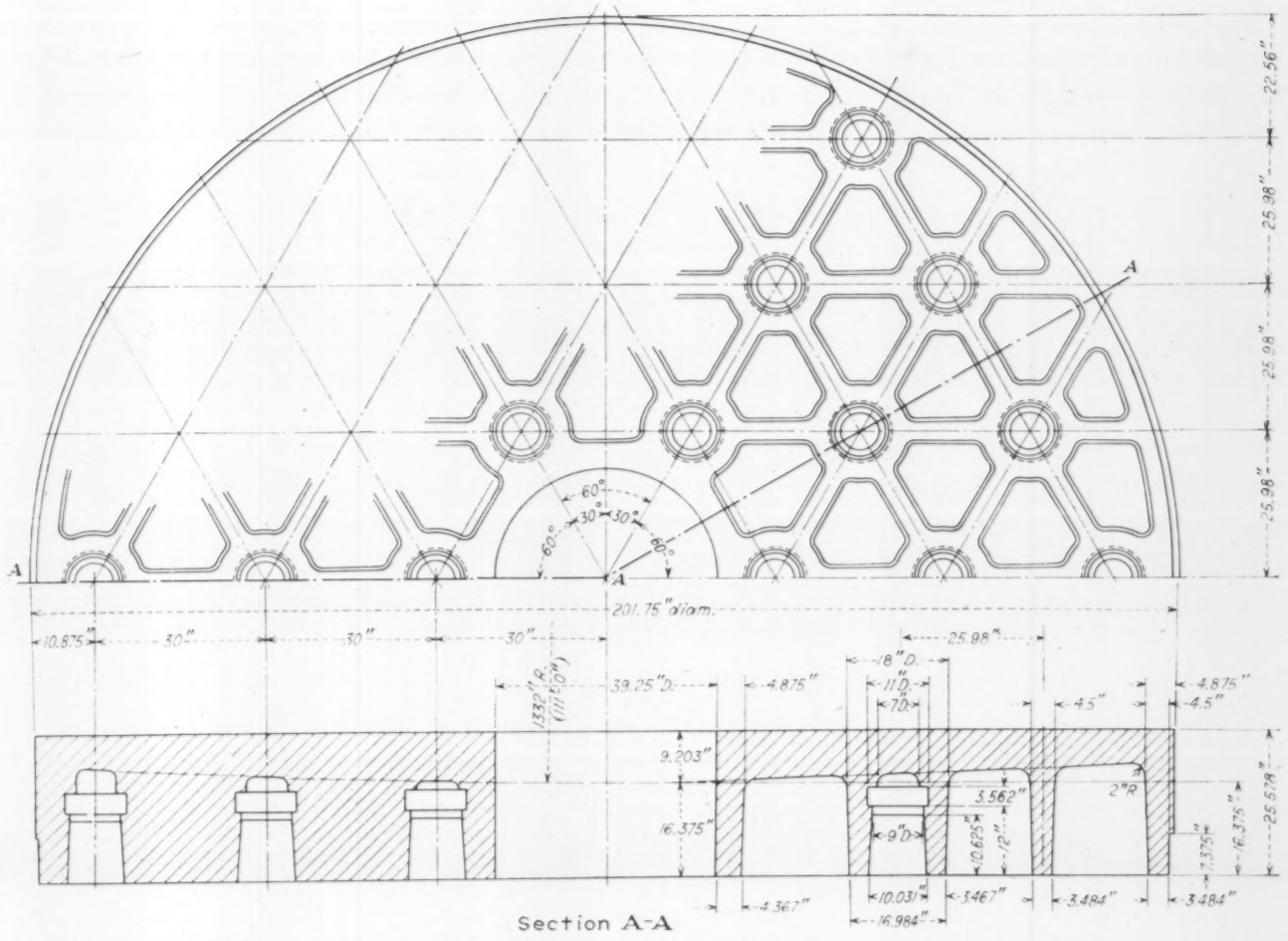


FIG. 9 PLAN VIEW AND CROSS SECTION OF GLASS MIRROR OF 200-INCH TELESCOPE

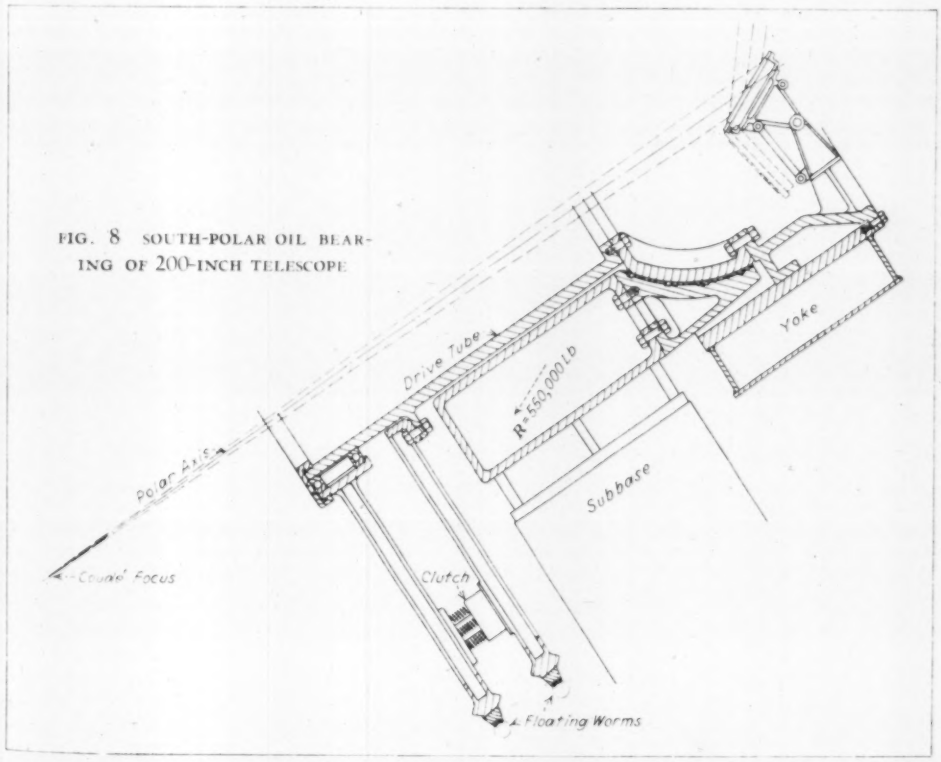


FIG. 8 SOUTH-POLAR OIL BEARING OF 200-INCH TELESCOPE

Fig. 8 seems preferable. It has friction torque at driving speeds of about 15 ft-lb, as compared to about 7000 ft-lb in case of a double-thrust and radial-load ball bearing.

The tube rotates around the declination axis on trunnions and means are provided for centering the declination axis at right angles to the polar axis and in the same plane as the polar axis. Either ball bearings or roller bearings can be used satisfactorily for the declination axis. In order to prevent deflections of the yoke from impressing strains on the tube, an elastic gimbal has been provided of a design somewhat similar to the bicycle wheel. A gimbal of a more conventional ball-bearing type has been studied also and can be supplied as a substitute if necessary.

The tube will be balanced about the declination axis and means will be provided for compensating for any changes in

weights due to use of different auxiliary mirrors or other attachments. Similarly, the yoke will be balanced about the polar axis and means will be provided for maintaining this balance.

The tube will be turned in declination by means of a worm and worm-wheel and it is proposed that this worm will be floating so as to maintain its position in relation to the wheel unaffected by deflections in the mounting. The mounting will be driven in right ascension in a similar way with worms and worm wheels in case the oil pad supports are used, and these worms will be at the south end as shown in Fig. 8. I have said "worms and worm wheels" because it appears desirable at present to provide one worm wheel for the fast motions and a second one, which can be declutched, for the driving speeds. Since the load on a single worm would be much greater at the higher speeds than the driving speed, the additional wear of the worm and wheel would produce a gradual loss in precision. For this reason the second worm, used only at the slower speeds, would remain more accurate over a period of time. We have set, as a desirable limit for the drive of these worms, an accuracy of one second of arc with a fine or slow speed, and ten seconds of arc for the high speeds.

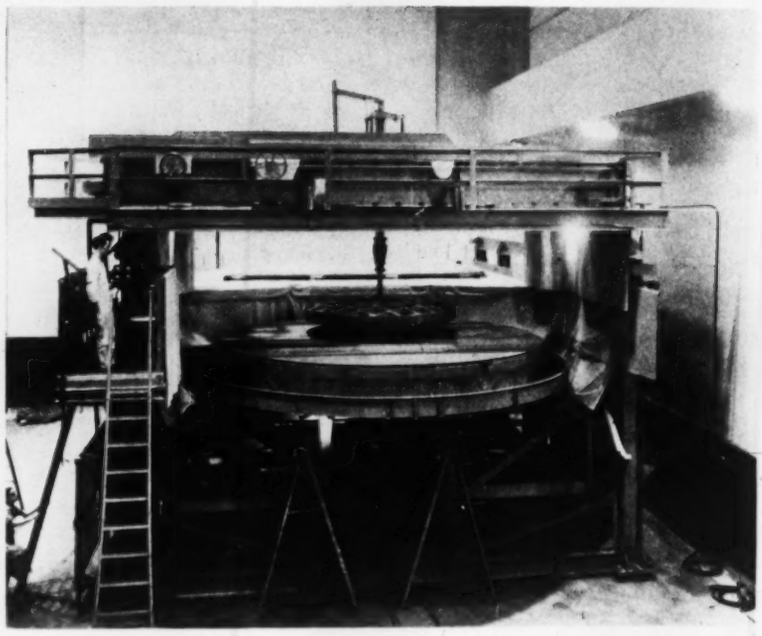


FIG. 11 GRINDING MACHINE FOR 200-INCH TELESCOPE MIRROR

DRIVING AND CONTROL OF TELESCOPE IN POSITION

There are various systems under consideration and the exact design that will be followed has not been determined. It is necessary to drive the telescope in right ascension from 105 deg east of the meridian to 105 deg west of the meridian and it is necessary, in declination to move the telescope from 57 deg south of the zenith to 91 deg north. The fast or setting speed in right ascension and declination will be approximately 45 deg per min and the acceleration from rest to maximum setting speed will require ten seconds. The normal driving speed in right ascension is 15 minutes of arc per minute. The drive must have a maximum smoothness of motion and have no sudden errors in excess of $^1/_4$ sec or periodic errors of this amount in less than 20 sec of time. By means of compensators it is possible to correct for changes in refraction and errors in gear cutting, and it is proposed, by use of such corrections, to maintain the object at all times within one second of arc of the center of the field.

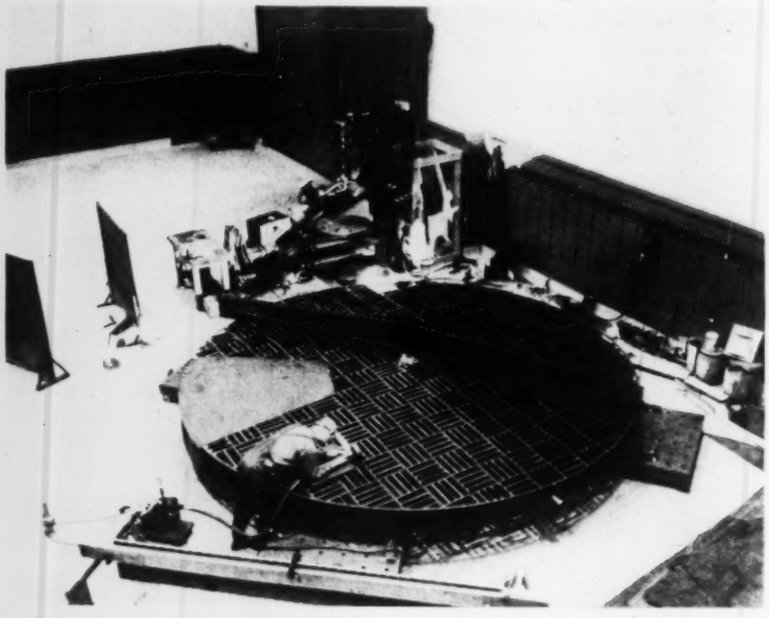


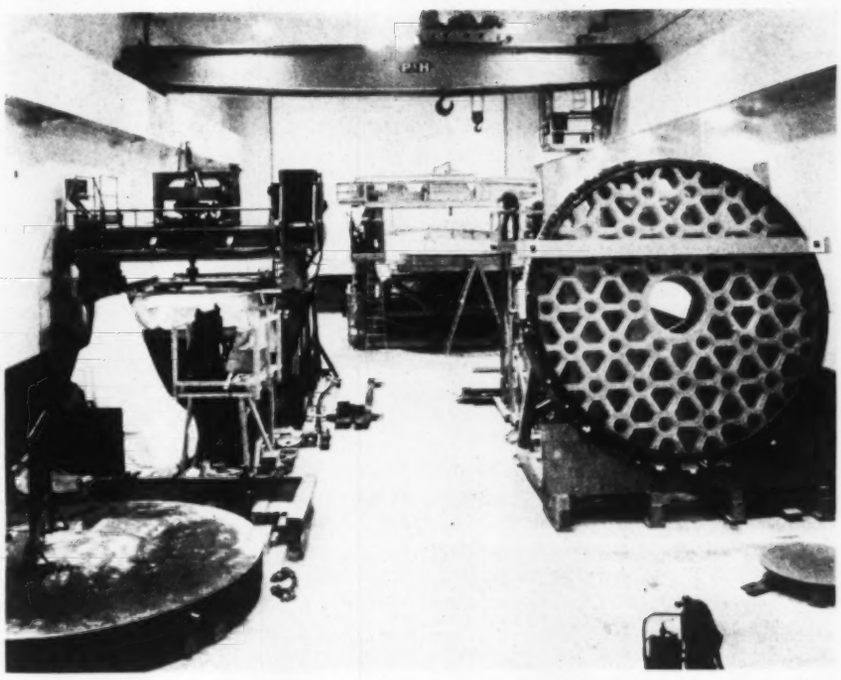
FIG. 10 GRINDING TOOL, PARTIALLY COMPLETED, FOR 200-INCH TELESCOPE MIRROR

DOME

It is necessary, of course, to tie the telescope to the ground, to provide covering for protection from the weather, and to provide storage for auxiliary apparatus and photographic rooms and other facilities for operating the telescope. These functions are all included in the dome, Figs. 1 and 2.

The dome itself will be a building some 135 ft in diameter and approximately this height from the ground level to the top. The stationary part up to the operating floor will be 26 ft above the ground and will be made of concrete and steel. The upper part of the dome must rotate and carry an opening for the line of sight of the telescope with a shutter that can be closed when the telescope is not in use. This rotating part of the dome will be mounted on tracks and must rotate smoothly so as not to transmit vibrations through the structure to the telescope. The dome will be insulated to maintain during the daytime, as nearly as possible, the same temperature around the telescope as is maintained at night.

The foundations and pedestals for the telescope and its mounting will have a substructure of concrete with the steel sub-base and pedestals. All of this structure will be separated and isolated from the foundations for the dome itself.



VIEW OF OPTICAL SHOP WITH 200-INCH MIRROR AT RIGHT

group concerned with the design of this structure hopes to make this a fine monument to that long line of telescope builders which began with Galileo and Newton.

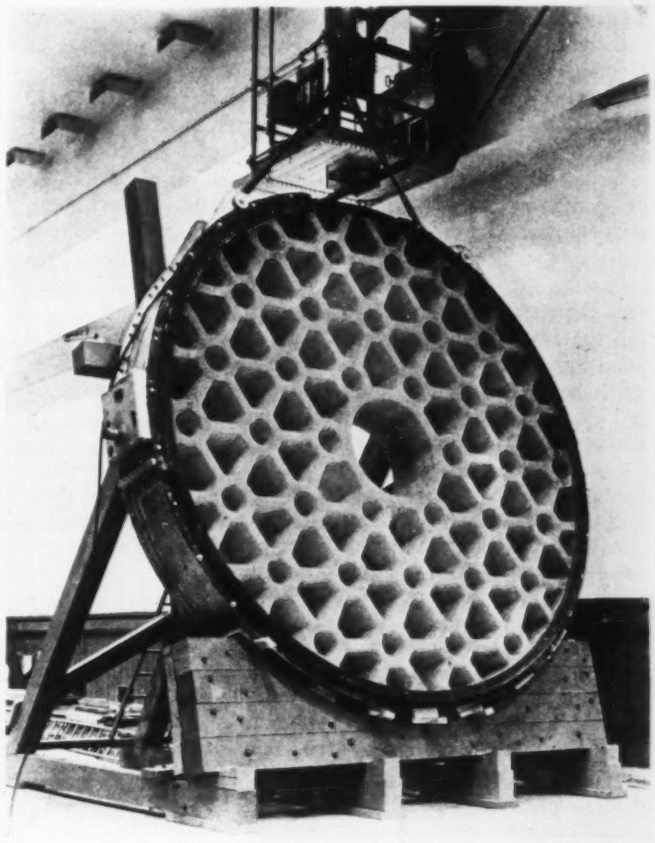
[NOTE: For a description of the principles of equatorial reflecting telescopes see "A New 60-In. Telescope for Perkins Observatory, Ohio Wesleyan University," MECHANICAL ENGINEERING, March, 1924, pp. 113–117, and "The Mechanics of the Telescope," by E. P. Burrell, MECHANICAL ENGINEERING, vol. 53, April, 1931, pp. 255–261. For a description of a dome-operating mechanism see "McDonald Observatory Dome," by E. N. Jennison, MECHANICAL ENGINEERING, June, 1935, pp. 349–354. The first of these articles points out the difference between the refracting and the reflecting telescope, and describes the various optical combinations, such as prime focus, Newtonian, and Cassegrain, used with reflecting telescopes. The second contains a brief review of the development of the astronomical telescope from the time of Galilei to the present day and a discussion of the manner in which the various mechanical problems encountered in telescope design have been attacked and the results that have been accomplished.—EDITOR.]

MIRROR

The mirror is made in the form of a parabolic surface with a grid back having thirty-six individual pockets in the back for support mechanisms, Fig. 9. The depth of the glass between the ribs is approximately 4 in. The ribs are 21 in. average depth and about 4 in. thick, so that all points within the glass are not greater than 2 in. from the surrounding air. The glass is a special material having a low coefficient of expansion, and the structure of the mirror is such that it assumes a uniform temperature throughout in a very short time. The rib construction (see frontispiece) also provides maximum stiffness with a minimum of weight. The multiple-support mechanisms take the down and side loads at the center of gravity at that particular section and prevent any excessive localized strains and consequent deformations of the glass. The mirror will be ground and polished to a final accuracy of 1/20 of a wave length throughout its surface or one millionth of an inch. Fig. 10 shows the grinding tool and Fig. 11 the grinding machine.

The surface of the mirror is to be coated with aluminum by a process which has been one of the research developments of this project. The use of aluminum as a reflecting medium provides two decided improvements. It has longer life than the silver-surfaced mirrors; exactly how much is not yet known, but whereas the silver-surfaced mirrors on Mt. Wilson had to be resurfaced every six months, aluminized mirrors have been in use for three years with very little loss of reflectivity. This aluminum also has the great advantage of giving something like 100 per cent increase in light at the ultraviolet end of the spectrum which, photographically, is a very important part of the spectrum.

The foregoing examples should serve to show, in general, the scope of this project. We have, however, reached that happy period in the design in which we no longer have any doubts about constructing a really fine instrument which will do all that is required of it. The entire



SHOWING HOW THE 200-INCH MIRROR WAS SUPPORTED FOR SHIPMENT

TRAINING PETROLEUM WORKERS

The Petroleum Industry's Vocational-Training Program in the Southwest

By A. W. BREELAND

LONE STAR GAS SYSTEM, DALLAS, TEXAS

IN 1917, the Congress of the United States enacted a law, known as the Smith-Hughes Act, which provides for trade and industrial education to workers in industry. Under provisions of this act, funds were made available for defraying 50 per cent of the cost of instruction for vocational-training classes, the act requiring that the additional 50 per cent be matched by local and state agencies. Education is a proper function of government, but in carrying on vocational, evening-class instruction, some organization must cooperate with governmental agencies in order to make it available to the workers in an industry. In the petroleum industry, the American Petroleum Institute, through its Division of Production, accepted this responsibility.

EARLY TRAINING PROGRAMS IN PETROLEUM INDUSTRY

For several years some of the major companies in the petroleum industry had carried on employee-training programs, but instruction was principally to train personnel in the sale of the company's products. Night schools in the larger cities had offered courses of general application to the petroleum industry. A few enterprising superintendents and foremen had conducted special classes for workers, teaching some mathematics and physics as applied to special jobs. Some of the major companies had carried on foremen training through their own organizations and also through the state vocational departments. But it was not until the early part of 1933 that vocational training, as made available by the Smith-Hughes Act, was given serious consideration by the oil companies in the Southwest, although considerable progress had been made in Pennsylvania where an elementary extension-school course in petroleum and natural gas had been developed and taught by the Pennsylvania State College and the Pennsylvania Department of Public Instruction.

In the Southwest among the first companies to offer vocational training to their employees were the Lone Star Gas Company, the Marland Oil Company through its Marland Industrial Institute, the Humble Oil Company, and the Cities Service Oil Company. Some of the major companies had been carrying on training programs through correspondence courses. The Lone Star Gas Company in starting its educational program in 1923 cooperated with one of the leading correspondence schools in making available to its employees courses through correspondence. The courses offered were principally mechanical, civil, chemical, and electrical engineering, surveying and mapping, internal-combustion-engine operation, and various high-school subjects. More than 600 employees have enrolled for these correspondence courses during the 13 years this program has been in effect, and more than 200 have completed the courses. While this type of an educational program is beneficial, it does not reach the majority of employees because many of them do not have the necessary basic education to permit them successfully to complete the courses. Moreover, many men hesitate to sign up for correspondence courses requiring several months and in some instances even years to complete.

The first vocational evening classes in the petroleum industry in the Southwest were offered by the Marland Oil Company (now Continental Oil Company) to its employees at Ponca City, Okla., in 1926, through the Marland Institute; and the work done by this organization, although short-lived, has been helpful in the promotion of our program. The first classes in Texas were offered by the Humble Oil Company to its employees at Baytown in 1929. Semitechnical subjects, such as blueprint reading, welding, pipe fitting, and mathematics, were offered at these places.

A PROGRAM ORGANIZED FOR THE SOUTHWEST

Recognizing the need for an organized program of vocational education in the petroleum industry in the Southwest, the safety directors of some major companies inquired of the vocational supervisors during the several foremen conferences whether such a program could be offered through their organizations. As a result of these inquiries, the supervisors of vocational education of the states of Texas, Oklahoma, and Kansas met with safety and educational leaders of the industry in the office of the Division of Production of the American Petroleum Institute at Dallas in April, 1933, to formulate plans for a suitable vocational educational program for the industry.

Conclusions were reached at this meeting that the following work should be undertaken:

(1) Development of a course explanatory and descriptive of the industry.

(2) Development of specific courses applicable to the various kinds of work in the industry.

(3) Provision for an agency within the industry to assist in carrying on this work.

As a result of this meeting, the supervisors of vocational education of the states of Texas and Oklahoma were invited to appear at the 1933 midyear meeting of the American Petroleum Institute in Tulsa, Okla., to explain their part in the promotion of an industrial-training program. At the annual meeting of the institute in Chicago in 1933, the central committee on district activities of the American Petroleum Institute decided to appoint a topical committee on vocational education to act as a correlating and validating committee on text material. Mr. Walter Meier, of the Atlantic Oil Company, was selected as chairman, a position which he now holds. It has been my privilege to serve as a member of this committee since its organization and at present in the capacity of secretary. This committee has met regularly each quarter, and its function has been:

(1) To prepare an outline of subjects on which text material should be prepared.

(2) To assign the subjects to the state vocational representatives for developing and writing the texts and to eliminate duplication of effort.

Contributed by the Committee on Education and Training for the Industries for presentation at the Semi-Annual Meeting, Dallas, Texas, June 15–20, 1936, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

(3) To select operating men to assist the state vocational representatives to prepare texts that will have practical application to the petroleum industry.

(4) To review and validate text material before publishing.

(5) To assist the federal and state representatives in a general advisory capacity.

SUBJECTS OF INSTRUCTION AND PREPARATION OF TEXTS

This committee, after several meetings, decided that the courses of study should be divided into three sections: Basic, general, and specific courses. Grade review work and elementary science and mathematics as related to the petroleum industry have been included under basic courses. The mathematics text has been divided into two sections—one elementary and the other including higher mathematics. The grade review text was prepared for men who have had little if any opportunity to attend school.

In the general-course series, eight subjects have been selected to date for text material, which are as follows: Internal-combustion engines; steam power; surface pumps; electric power; story of petroleum; oil-field transportation; blueprint reading; motor-vehicle driving.

Under the specific series six texts have been selected as follows: Drilling practices; production practices; construction practices; natural-gas production; natural-gasoline manufacture; pipe-line operation.

In the preparation of texts to be used in the vocational evening classes, the representatives from the several state departments of education have been instructed to keep ever in mind that many of the workmen have had little more academic training than the eighth grade and that as much theory as possible should be deleted in preparing the material. They were also instructed to include in the text problems as many practical applications as possible. The texts are profusely illustrated with pictures and sketches of equipment actually used in the industry. The actual routine of preparing the text by the representative of the vocational department assigned to write it is first to prepare an outline, which is then reviewed by the members of the topical committee and also by practical men in the industry. After the outline has been reviewed and corrected, it is validated by the committee. The author then writes the text and submits it to the topical committee for validation, after which it is printed.

In teaching such subjects as the maintenance and operation of internal-combustion engines, welding, pipe fitting, blueprint reading, and sketching, the instructors who have been most successful have been those who took their classes into the workshops and engine rooms and had the men actually perform the operations they were studying. Internal-combustion engines were completely dismantled and reassembled. One and sometimes two lessons were devoted to such subjects as lubrication, ignition, and ring wear.

In selecting the general and specific subjects for textbooks we have been guided by the demand from the employees for such subjects.

SELLING THE PROGRAM TO THE WORKER

After the organization of this committee, which was composed of representatives of the state departments of vocational education of Texas and Oklahoma and men in the industry who were interested in the promotion of adult education, the next problem was that of selling the program to the men. In my opinion, for an educational program to be successful it must be strictly voluntary on the part of the workmen. This plan was followed in most of the companies in the petroleum industry in the Southwest and companies that promoted their programs on this basis have been most successful in their training programs.

Because vocational training was practically unknown to many of the more isolated school districts, much missionary work had to be done by the vocational departments of education of the several states in organizing local school authorities to carry on this work. The hearty cooperation received from the public-school authorities and the department of vocational education of the several states has been most helpful and gratifying.

In the promotion of this work in our own company, we simply called to the attention of our employees the courses which were available in the evening classes in their respective districts. We informed them that through cooperation with the federal and state governments they would be able to enroll for these courses and that the only expense to them would be the cost of the textbooks and the time which would be required in attending the classes. As an example of the first response to this program, in one district where we had approximately 300 men, about 150 indicated a desire to enroll in the first class offered, which was in elementary science. When the men received their textbooks and began talking about them to the other employees, enrollment reached 253 and the attendance in this district was approximately 90 per cent. The enthusiasm with which the courses were received and the classes attended by our workmen was beyond my fondest imagination.

As a further example of the interest with which this program has been received in the Southwest, in the fall of 1933 there were approximately 3000 students enrolled in vocational evening classes in Texas and Oklahoma, in 1934 approximately 6000, and in 1935 approximately 3000. An average attendance of 90 per cent at classes is evidence of the interest which the workmen have in self-improvement. The drop in registration in 1935 is not a reflection of the interest in courses but is due to the fact that the first courses to be offered were the basic and it was natural to expect a larger registration in these subjects than in the courses applying to some particular subject. We still have classes in elementary science and mathematics as related to the petroleum industry, but a majority of the workmen in the Southwest who are interested in vocational evening-class instruction have now completed these two subjects, and most of those enrolled for classes for the school year of 1935–1936 are interested in some specific courses, such as internal-combustion engines, steam power, and welding.

The Smith-Hughes Act provides that workers may take only vocational courses which are related to their particular industry and that at least ten students must be enrolled in each class. When as many as ten or more workmen desire to enroll in any of the petroleum-industry series courses, contact is made with the local school superintendent who proceeds to organize the classes.

Certain qualifications are necessary for instructors selected to teach the various classes. One of the principal requirements is that the teacher shall have shown evidence of leadership and that he must have experience in the work in that particular field. It is not necessary that he be a graduate of a college or high school, but he must have sufficient experience to interpret adequately and logically the text material.

Adult education presents quite a different problem from that of child education. In few classes will the same level of education be found among the students. It therefore becomes necessary for the teacher to give much individual instruction if he is to be successful. Furthermore, the men will usually know the practical side of the operations of their jobs and the instructor must, therefore, be able to present the

theoretical side in a logical way. Surprising as it may seem, in many of the classes high-school and college graduates will be found with the student who has not even completed grade-school subjects.

In my opinion, the fact that many high-school and college graduates have attended the vocational evening classes is evidence of the excellent manner in which the text material has been assimilated and prepared. In teaching, no distinction has been made between the superintendent and the roustabout. They meet in the classroom on a common ground and frequently the supervisor is able to get a better understanding and appreciation of his workmen in the classroom than on the job.

VALUE OF THE TRAINING PROGRAM

One of the reasons for vocational training in industry is to give to the employee a greater appreciation of his industry. From the workman's standpoint, vocational training is highly desirable for several reasons, among which are the following:

Processes and methods are changing and if a workman is to keep up with the trends in his industry, it is essential that he study some aspect of it outside of his particular job.

The day of specialists in the industry has changed. While it is true that we continue to have, and will always have, need for specialists in certain lines, nevertheless the time is here when a man in the power plant needs not only to know how to time an engine and pack a valve, but he must also be a machinist, electrician, pump expert, and all-round repairman as well. It becomes necessary, therefore, instead of specializing in one operation that he become familiar with every piece of equipment in his plant. Particularly is this true in the petroleum industry where there are countless hundreds of small, isolated stations and plants with usually only one man on duty at a time.

At the time the petroleum industry's vocational-training program was organized, the average workman's hours had been reduced considerably and therefore, he had more leisure for study or other purposes. It was felt that our workmen would welcome an opportunity to improve themselves during this leisure time. Our experience has certainly verified this conclusion.

The competition for jobs has also become keener and employers are more exacting in their requirements for trained men. Furthermore, a man who is trained not only to do a job correctly, but who knows why he performs operations in a certain manner, who understands the theory as well as the practice, is certainly a more satisfied workman and naturally takes more pride in a job well done.

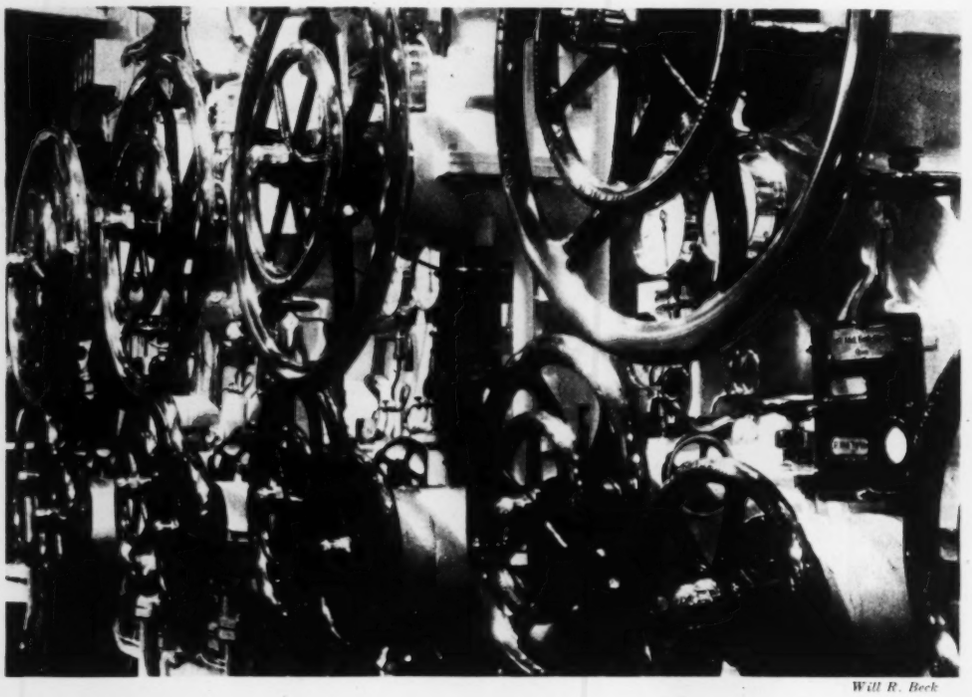
And last, but not least, earning capacity and the possibility for promotion and a higher standard of living, increase with training.

The employer also gains many advantages from a well-organized vocational-training program. When a man has a knowledge of the background of his industry, of the problems that confront it and his company, and of his own job, he will take more interest in his job and in his company, and costly labor turnover will, therefore, be reduced to a minimum. Increased efficiency naturally follows a good vocational-training program. Moreover, the company or industry that promotes a constructive vocational-training program creates a more favorable impression in the mind of the public.

Often, as a result of a vocational-training program, hidden talent is discovered and square pegs can be removed from round holes and made to serve a more useful purpose in the company.

In my opinion industry has at least three major obligations to fulfill—to the public it serves; to itself; and to its employees. An important part of each of these obligations can be fulfilled through the promotion of a constructive vocational-educational program for the employees within that industry.

Grateful acknowledgment is made by the author to Messrs. Ray L. Martin, State Supervisor of Vocational Education, Austin, Texas, L. K. Covelle, State Supervisor, Trade and Industrial Education, Oklahoma A. & M. College, Stillwater, Oklahoma, and W. Fred Heisler of the Department of Trade and Industrial Education of Oklahoma, for valuable assistance in the preparation of this paper.



Will R. Beck

STREAMLINING— FACTS *and* FANCIES

How Railroads Are Receiving the Application of Aerodynamics

By L. K. SILLCOX

NEW YORK AIR BRAKE COMPANY, WATERTOWN, N. Y.

STREAMLINE flow and aerodynamic resistances are not problems that are unique in the experience of railway mechanical officers. They were evident in 1829, when Stephenson conceived the idea of directing the exhaust from the cylinders of the "Rocket" through the stack, first to quiet the exhaust, and then, ultimately, to brighten the fire and accelerate the rate of combustion. Attempts to smooth out the path of fluid flow have been restricted in the past to consideration of effects within the locomotive. The exterior has just now been given careful and practical aerodynamic treatment of contour. Yet even here the thought is by no means novel.

U. S. patent 489,911, issued to Frederick U. Adams in January, 1893, in which claims were made for a scheme whereby the conventional passenger train of the period might be effectively streamlined to reduce air resistance, had not been discussed for almost half a century until the present interest was manifested in streamlining, as an indication of modernization. The Baltimore and Ohio Railroad, which equipped a train to obtain the advantages which the streamlining advocated by Mr. Adams promised, did not choose to publicize the pioneering of this project, which was the forerunner of a now familiar trend, since tests demonstrated the plan to be impractical. Today, however, in view of the impetus which the fairing of contours and concealment of appurtenances is receiving by public demand, memory of this first experience has been revived and nearly every one must now be familiar with the appearance of the first railway equipment to be consciously streamlined. The Adams train, with its unmodified locomotive, carrying a high stack and long, pointed pilot, coupled at the head of the first vestibuled cars, their enveloping shrouds reaching to the rails, confronted the problem that still remains the most perplexing. The exposed side area was increased to the point that cross winds pressed the wheel flanges against the rails with a force that offset any advantage that the train might otherwise present. The test results were discouraging. The measured resistance indicated no improvement over that obtained with standard equipment sufficient to justify the adoption of the practice, and it can be confidently stated that, had speeds less than those now practiced, and the higher ones in prospect, been demanded by traffic, no promise of saving in power requirements would ever influence the railways to revive shrouding as an economical venture.

Prof. Alexander Klemin has derived the extent to which streamlining may reduce that part of total train resistance which is represented by the displacement of the air mass through which it moves. The proportionate economy then depends upon the relation observed between air resistance and the total force which the motive-power unit must exert to maintain train speed. These other resistances are represented by first, the machinery friction which diminishes the force exerted at the rails of the steam locomotive, or the transmission losses if electric propulsion is employed; second, the friction at the journals of all trailing cars; third, the energy absorbed by suspension springs, originating with imperfection of track surface and with components of weight transfer occasioned by changes in the rate of acceleration and by lateral thrusts; fourth, the interaction of all contacting surfaces in car bodies, trucks, couplers, draft gear, and buffers; and fifth, the friction between the guiding flanges of the wheels and the rail heads. These resistances have been found to be best represented by some values which are constant at all speeds together with others which are directly variable with the first power of speed. Of even greater significance, when the relative value of reduction in the air-resistance component is considered, is the effect of route profile which adds 20 lb per ton (2000 lb) of train weight to whatever other resistance values are impressed for each one per cent of adverse grade (52.8 ft per mile).

DAVIS EQUATION FOR TRAIN RESISTANCE

The Davis equation for train resistance is probably the most familiar instrument employed for the calculation of effort required to propel railway equipment. It recognizes the existence of resistance factors which apply in the manner outlined and it is expressed in the general form

$$R = A + BV + CV^2 \quad [1]$$

where R = train resistance
A, B, and C = constants
V = speed

More specifically, the Davis equation is presented as

$$r = 9.4/\sqrt{w} + 12.5/w + kV + k'AV^2/wn \quad [2]$$

where

r = resistance, lb per ton
w = average weight per axle, tons
k and k' = constants
A = projected area of largest cross section of equipment considered, sq ft
n = number of axles
V = speed, miles per hour

The first two terms of Equation [2], $9.4/\sqrt{w} + 12.5/w$, assume the approximate value $1.3 + 29/w$, and the equation is so written in most applications.

Under various conditions of equipment type and location

Contributed by the Aeronautic Division, and presented at a meeting, New York, N. Y., April 27, 1936, of the Metropolitan Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

of cars within a train, k and k' have been assigned the values, experimentally derived, given in Table 1

TABLE 1 VALUES OF k AND k'

	k	k'
Steam and electric locomotives		
Conventional, nonstreamlined form	0.03	0.0024
Partially streamlined (well-faired)	0.03	0.0015
Passenger cars	0.03	0.00034
Multiple-unit cars (leading)	0.045	0.0024
Multiple-unit cars (trailing)	0.045	0.00034
Motor cars	0.09	0.0024

This series has been expanded to present the approximate value of the constants applied to the modern, high-speed, articulated trains. These define with reasonable accuracy the resistance components as they have been experimentally obtained.

Streamlined, articulated trains	k	k'
Leading car	0.045	0.00055
Last car	0.045	0.00025
Intermediate cars	0.045	0.00020

The loss in transmission of power from steam-locomotive cylinders, Diesel-engine crankshafts, or electric-locomotive current collectors, to the rims of driving wheels is not included in this expression but is taken as a function of motive-power efficiency.

The Davis equation may be readily separated into its three major components: (1) Journal and machinery resistance which is assumed to be independent of speed; (2) flange friction, and the oscillation, vibration, and dynamic friction effects, variable with the first power of the speed; and (3) air resistance, which varies with some power of speed approaching the square. No effect of side or head winds is considered in the basic equation.

TWO TYPES OF TRAINS COMPARED

The Davis formula has been applied with its various modifications to establish the ratio of air resistance to total resistance for (1) a conventional passenger train, consisting of a 320-ton locomotive and eight, 84-ton cars, traveling on level, tangent track at a speed of 70 mph; and for (2) a four-car, high-speed, streamlined, articulated train of 115 tons total weight, traveling at 110 mph. The calculated resistance values are submitted in Table 2, which also gives the relative effect of air resistance, were the selected operation on an ascending grade of 0.5 per cent.

TABLE 2 OPERATING COMPARISONS—CONVENTIONAL STEAM TRAIN AND HIGH-SPEED, LIGHT-WEIGHT ARTICULATED TRAIN

	Conventional train	Streamlined train
Gross weight, tons	992	115
Speed, miles per hour	70	110
Air resistance, lb	3152	1210
Total resistance, level track	8320	2226
Air resistance, per cent of total	38	54.3
Total resistance, 0.5 per cent grade	18240	3376
Air resistance, per cent of total	17.3	35.9

Reliable information concerning that part of train resistance which is due to the air is not easy to find even under existing circumstances, for, dissociated from the trains which provide the data on which they were based, most formulas give erroneous and misleading information. Particularly is this so of formulas which pretend to give the total resistance in pounds per ton and which show this figure to be a function of the speed alone. Such a formula is wrong even for trains made up of the same types of motive power and rolling stock as were employed in the experimental runs, its indication being correct for only one particular length of train. For other lengths the coefficient of the V^2 term should be changed, which means that, for purposes of quotation, the formula employed should be bracketed with this particular length. The common assumption that the V^2 component of train resistance is proportional to the weight makes it proportional to the length also. Actually, the frontal and rear resistances, which are more or less the same for long and short trains, are smaller per ton weight or per foot of length for long than for short trains.

These selected trains may be considered typical of two classes of modern service. They are in no sense parallel. The light-weight, four-car train will accommodate 90 to 100 passengers and 25 tons of mail and baggage. The eight-car conventional train, consisting of locomotive and tender, one combination mail and baggage car, two standard coaches, three pullman-parlor cars, and two sleeping cars, will offer several times the revenue-producing capacity. On the space-weight-capacity basis of the light-weight train, the mail and baggage car of the conventional train will carry approximately 50 tons. The coaches will accommodate 170 seated passengers, there will be space for 100 in the three parlor cars, one of which may be equipped for buffet service, and the two standard sleeping cars provide berth or drawing-room accommodations for 52 more. The steam-locomotive train then provides for twice the head-end tonnage and from three to three and one half times the passenger capacity, with two cars devoted to sleeping accommodations which are not furnished in the four-car light-weight train. In many cases a lounge car will be provided to offer still greater freedom to passengers of the conventional train, further improving a part of the service in which the conventional train already excels by a wide margin. This relationship must be borne in mind in the comparisons which follow.

Even though the light-weight high-speed train is quite effectively streamlined, whereas the steam-locomotive train is not, air resistance consumes a considerably greater proportion of total train horsepower in the former case. Two factors contribute to this effect. First, of course, is the higher speed at which the train is operated. Although the higher speed is but 57 per cent greater than that of the steam train, the increase in air resistance per ton of train weight between these same speeds is 225 per cent. Second, streamlining was not the only measure employed to reduce the resistance of the light-weight trains. Weight was drastically reduced, articulated construction adopted, roller bearings installed, and the least outside dimensions consistent with passenger comfort employed. These factors have been much more instrumental in reducing power requirements to effect a given passenger-mile service than has the fairing of the body form. A 55 per cent reduction in the relative importance of air resistance in the case of the 1000-ton train is shown as the result of introducing operation on a grade of but 0.5 per cent. Were the articulated train to operate on such a grade, the importance of air resistance would be reduced 34 per cent. Every comparison of this nature points to one, seemingly inevitable, conclusion—that the streamlining of railway locomotives and trains may best be applied as a measure incidental to weight saving and optional contour if its cost is to be justified by the saving it effects. Trains do not yet operate on extended runs at sustained high speeds which render streamlining a primary consideration in the matter of power limitation.

It must not be judged from these remarks that streamlining is unimportant from the standpoint of power economy. Such is not the case whenever operating speeds exceed 60 mph

However, when the provision of streamlining involves an appreciable amount of additional weight, when it seriously interferes with freedom in design and the location of appurtenances, affecting maintenance costs, or when the initial cost of equipment is materially increased by introducing these refinements in body form, the balance of cost and economy must be carefully worked out if the decision rests upon the strict operating economy of the equipment. The streamlining of one high-speed passenger locomotive by fitting a sheet-metal shroud about an otherwise substantially conventional form added 13,000 lb of weight which might undoubtedly have been applied to better advantage for power-production rather than power-saving purposes, since tests have shown the measure of total drawbar-horsepower increase obtained by a practicable measure of streamlining to be no more than about 7 per cent at 90 mph. At 60 mph, the increase is approximately but 1.5 per cent.

LONG LIFE OF RAILWAY EQUIPMENT RETARDS CHANGE

Streamlining attracts favorable comment from the man who views the train. Rigid adherence to fast schedules, combined with the accepted standard of railway-car appointments, appeals to the man who avails himself of the service. While the latter individual will, at times, be a spectator, it is not as a spectator that he contributes to the support of the railway and the railway must appeal to more than his judgment as to what the appearance of a train should be. Untold ill will has arisen from the fact that the conventional railway train of today bears a marked resemblance to its equivalent of 10 and 20 years ago, but still more serious is the fact that, in many cases, it is truly the same train. During this same span of years the automobile, bus, highway truck, and airplane have undergone revolution of type. The life span of the automotive vehicle scarcely exceeds five years—that of airplanes is measured in hours. Styling of automobiles is necessary in a highly competitive market. Scientific investigation has required rapid transformation in the appearance of aircraft that advantage might be taken of progressive discoveries. Each change has added to the suggestion of capacity for speed, a pleasing tendency as viewed by a speed-conscious age. The automotive industry has adapted its designs to the pace set by aviation, hoping to gain some aerodynamic benefit while appealing to the public taste for smooth curves and extreme fairing. The railways have been compelled to fall in line irrespective of the measure of technical benefit to be realized.

It has not been found possible to retire railway locomotives and rolling stock at a rate which will permit railways always to present new equipment for the use of their patrons. Moreover, even when new equipment is furnished, it must adhere to certain fixed standards in order that it may associate with other and less modern types. In this respect, railways suffer a serious competitive disadvantage compared with the highway and airway services.

There are four principal reasons for the long life of railway equipment: (1) The most intensive use has not been attempted in the past; (2) the nature of railway operation requires the availability of vast reserves of serviceable equipment; (3) to satisfy railway requirements for strength and safety, extremely sturdy units are provided, which, by the very nature of their construction, remain serviceable over a period of many years, and (4) railway-maintenance practices, some of which are enforced by federal authority, retain the original characteristics of equipment throughout its life. A change is being witnessed in the first of these requirements—the only one over which railways exercise complete control. Long locomotive runs and quick turns, improved maintenance facilities and shop practices are permitting greatly increased annual locomotive mileage. Similarly, fewer cars are assigned to some important services, increasing the proportion of time that they are profitably employed.

Higher speeds increase the potential mileage per unit of time and, irrespective of the apparent basis, depreciation must recognize the amount of service rendered. As more intensive use is obtained, fewer units will be required to handle a given traffic, and, although the depreciation rate, adjusted on a time basis, must be increased, the net fixed cost will be no greater.

COMPARISON OF STEAM AND DIESEL POWER

New Diesel-electric equipment promises new possibilities for intensive utilization. Eight hundred miles per day with availability higher than 90 per cent is not an uncommon record with this type of unit. The Union Pacific will soon inaugurate a new Chicago-Denver service with two ten-car, streamlined, semiarticulated, Diesel-electric trains, operating on a schedule of one train a day in each direction over the 1048-mile route. If 90 per cent of the trips are completed, a new record of nearly 350,000 miles per year will be established. For high availability, the Diesel engine possesses important advantages. Fire cleaning, water requirements, certain federally enforced periodic inspections, and servicing for coal, when used, consume steam-locomotive time during which the comparable Diesel can produce additional ton-miles. Yet probably no one can state the limit of availability which the reciprocating steam locomotive can display. We operate on a more conservative basis when we use steam. It has been only within the last few years that continuous 600-mile runs have been attempted with steam and still little evidence is available to show that every effort is regularly made to operate a return trip with minimum delay. The underlying thought is that, with every effort exerted in the direction of maximum yet thoroughly dependable annual mileage, the retirement rate of steam motive power must approach that selected for Diesel equipment, both being replaced on a comparable mileage basis. Unless this can be done, with obsolescence becoming an increasingly important factor, the decided spread between fixed charges for the two motive-power types may be narrowed materially.

This factor of replacement period has become an item of real importance. The public is ever more critical of the equipment which is offered for its use. Moreover, it will never suffice to adopt current streamlined styling and expect that it may prove acceptable over a long period of time because public fancy is capricious in its demands and the ultimate in body contours today is judged ugly tomorrow. The solution would lie in a practicable and economical plan of operation, yet to be devised, which would permit the acquirement of new rolling stock, both locomotive and passenger cars, at a rate more nearly approaching that at which units are replaced by common-carrier highway operators.

PUBLIC OPINION AND STREAMLINING

Experience has shown that if a steam locomotive, standard in every respect and of conventional form and contour, is fitted with a shroud which presents the clean, sleek appearance which the public expects in equipment operated in 1936, the people will line the right-of-way to watch it pass, even though it runs on the same schedule and hauls the same cars that typified the train before this relatively unimportant modification was added. From a traffic standpoint, untold benefit may arise from the acceptance of a simple expedient. This factor must not be overlooked. Unless it is ultimately possible to replace equipment rapidly and with marked regularity, it may be necessary to construct locomotives with replacement shroud-

ing, altering form to comply with changing mode and fickle public preferences, retaining the essential equipment until the limiting mileage has been operated.

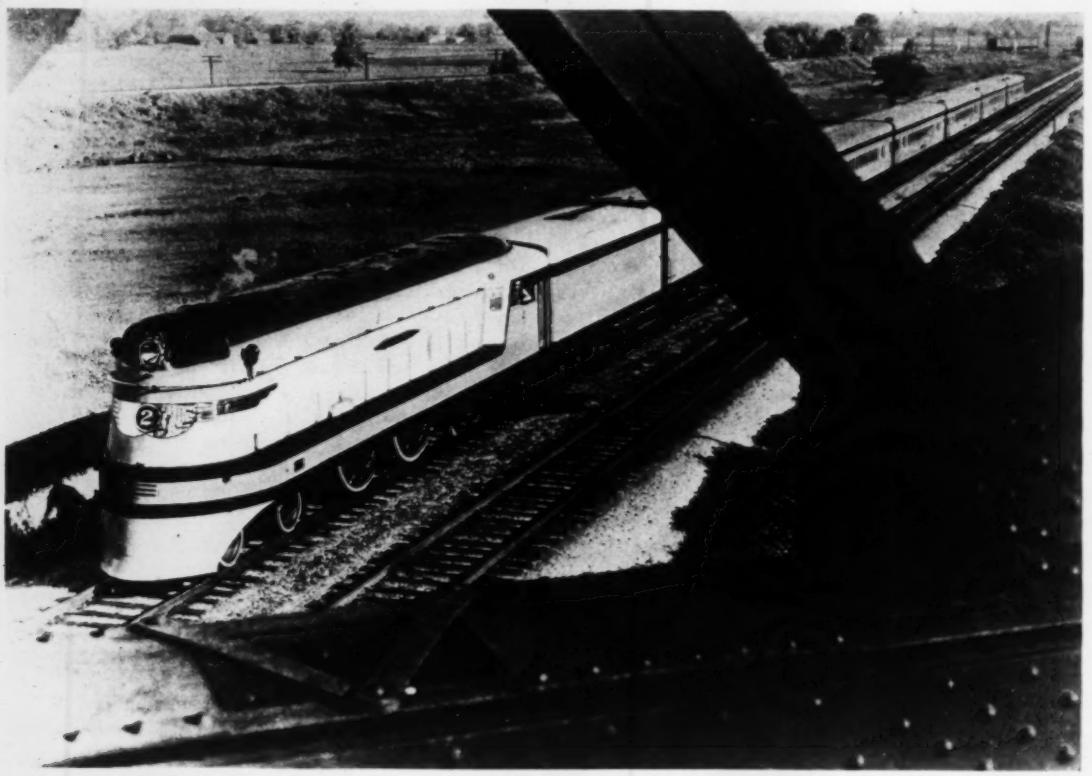
While streamlining has offered the most important advertising benefit which it has been the railways' privilege to exploit in many years, it would appear that the novelty of form will no longer attract notice except as extreme patterns are introduced. The country is familiar with the types of high-speed streamlined trains now in operation and they are all markedly similar. Speed and service are required with improvements beyond anything which has gone before. There is even evidence of dissatisfaction on the part of the public with the performance in speed which the new trains display. They are announced with broad claims for potential high speed. When the public learns that a 100 to 120 mph train is placed in revenue service on a 50 to 60 mph schedule, it feels that it has been deceived by misrepresentation, even though the maximum speed may be touched en route. The need is for more continuous running—an average speed which will support the train in its record for accelerated service. Streamlining is of no particular consequence when advantage is spasmodically taken of its benefits by spurts of speed which are infrequent and of short duration and streamlining can contribute nothing to schedules which are demoralized by track and terminal wastes of time. Unnecessary stops and delays at stations are most annoying, while intermediate speed restrictions seriously interfere with what might otherwise be very creditable high-speed performance.

LIMITED APPLICABILITY OF HIGH-SPEED TRAINS

A survey of the main-line trackage of the railways of the country reveals approximately 20,000 route-miles suitable for high-speed service, considering grade, curvature, and nature of traffic. Extend the survey to embrace a comparison of the high-, moderate-, and low-speed movements which share the rails on even this 10 per cent of the nation's railways, and the conclusion must be that the proportionate amount of railway equipment that will benefit materially by aerodynamic treatment of exterior form must be small indeed. It is probable that the small, streamlined "railbus" will become increasingly popular. If so, the number of units which require aerodynamic investigation will be increased since, even though very high speeds are not attempted in these essentially local services, air resistance represents a greater proportion of the total retarding force of single- or two-car units than is noted in the case of longer trains, and streamlining principles are more easily applied to these new and light-weight cars.

The discussion of railway aerodynamics has been related primarily to the familiar main-line train which must include in its consist costly, nonrevenue, de luxe equipment for the common use of all passengers. These cars must be spacious and well appointed. To relieve the burden of cost, such cars must be associated with a number of revenue passenger cars and the train is extended to the proportions of the familiar through trains of our important main lines. As unnecessary weight is removed by the application of new materials of construction, the control of air resistance will become a more and more important factor for reasons of economical operation. With studied design, it should also be possible to integrate aerodynamic treatment with the structure of the equipment without involving the excessive cost and weight which is observed in many cases.

However, until this need is acutely felt and rationally met, the justification for the streamlining of equipment for conventional services must reside in a large measure in the public approval of the practice for its basic justification.



THE "HIAWATHA"

A SULPHUR-MINING POWER PLANT, WITH WATER-SOFTENING PLANT AT LEFT

POWER *and* HEAT PROBLEMS *in the* SULPHUR-MINING INDUSTRY

By C. L. ORR

TEXAS SULPHUR COMPANY, INC., NEWGULF, TEXAS

SULPHUR, although known as a chemical element for only slightly more than a hundred years, has been a servant of man for fifty centuries. The early Greeks, Romans, and Egyptians used it for medicine, for bleaching cloth, for religious ceremonies, and as a material of war.

Until thirty years ago practically the entire world's sulphur supply came from the Island of Sicily where it had been mined by pick and shovel in both strip and shaft mines for generations. The ore so produced contained about 25 per cent of sulphur, which was recovered in furnaces somewhat similar to our early lime kilns. The furnaces were fired with ore, and from one third to one half of the sulphur was burned to generate sufficient heat to melt the remainder, which was then drawn off and cast into pigs.

SULPHUR MINING IN THE UNITED STATES

It has been known for many years that some of the salt domes along the coast of Texas and Louisiana contain sulphur. These deposits are honeycombed in the limestone caprock over the salt plug, at depths, generally, of from 500 to 1500 ft. In 1891 Herman Frasch secured his original patents on a process for mining these deposits by melting the sulphur underground with hot water and then pumping it to the surface in a molten state.

Frasch's early attempts were attended by many exasperating set backs and failures, and it was nearly 15 years later that sulphur mined by his process became a factor in world trade. During the last 30 years, however, the United States has produced its own requirements and has exported a considerable tonnage.

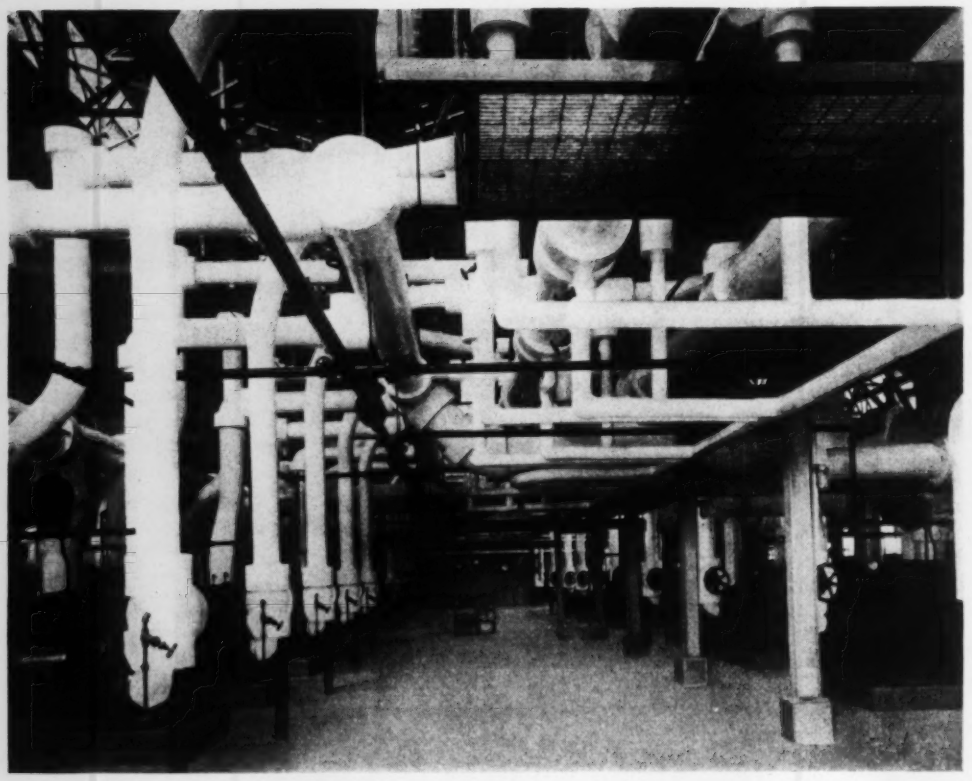
Although many improvements in materials, methods, and technique have been made, the basic Frasch process is used today in mining all the coastal sulphur. Frasch obtained steam for heating water from small horizontal-return tubular boilers.

Today water-tube boilers with 10,000 to 15,000 sq ft of heating surface and cooled settings are used. Frasch had to use reciprocating pumps for all pumping except that at very low heads, and most of the various corrosion-resistant alloys in use today were then unknown.

MELTED SULPHUR PUMPED FROM WELLS

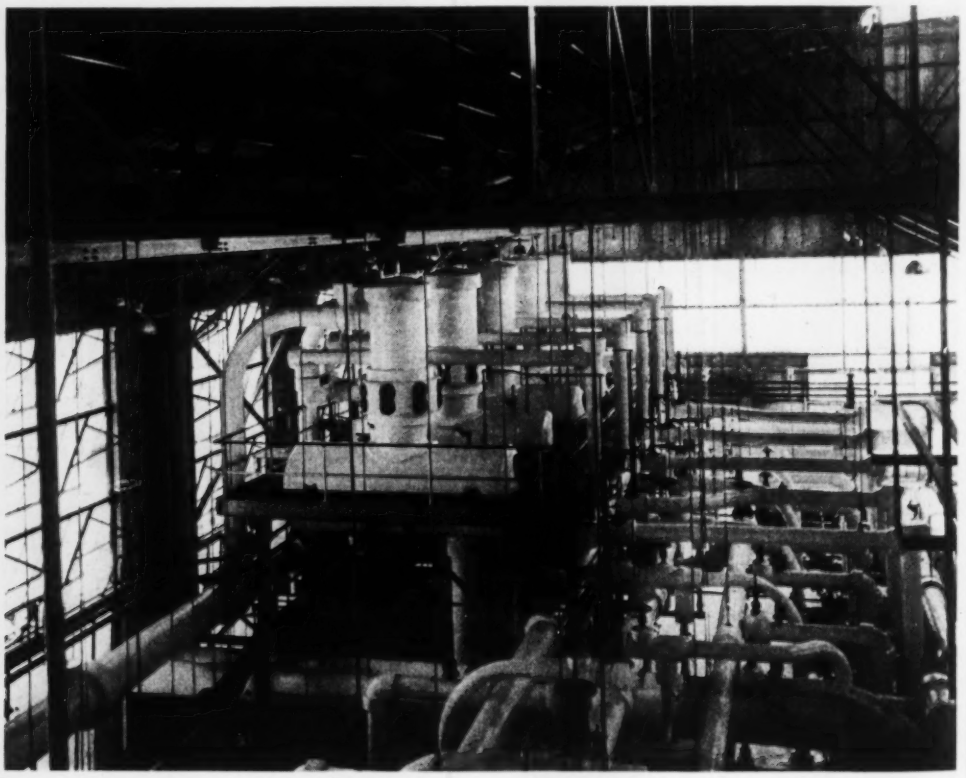
Wells are drilled to the bottom of the sulphur-bearing formation by rotary rigs and tools similar to those used in shallow oil wells. Surface casing is set and the well is equipped with con-

Contributed by the Power Division for presentation at the Semi-Annual Meeting, Dallas, Texas, June 15–20, 1936, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

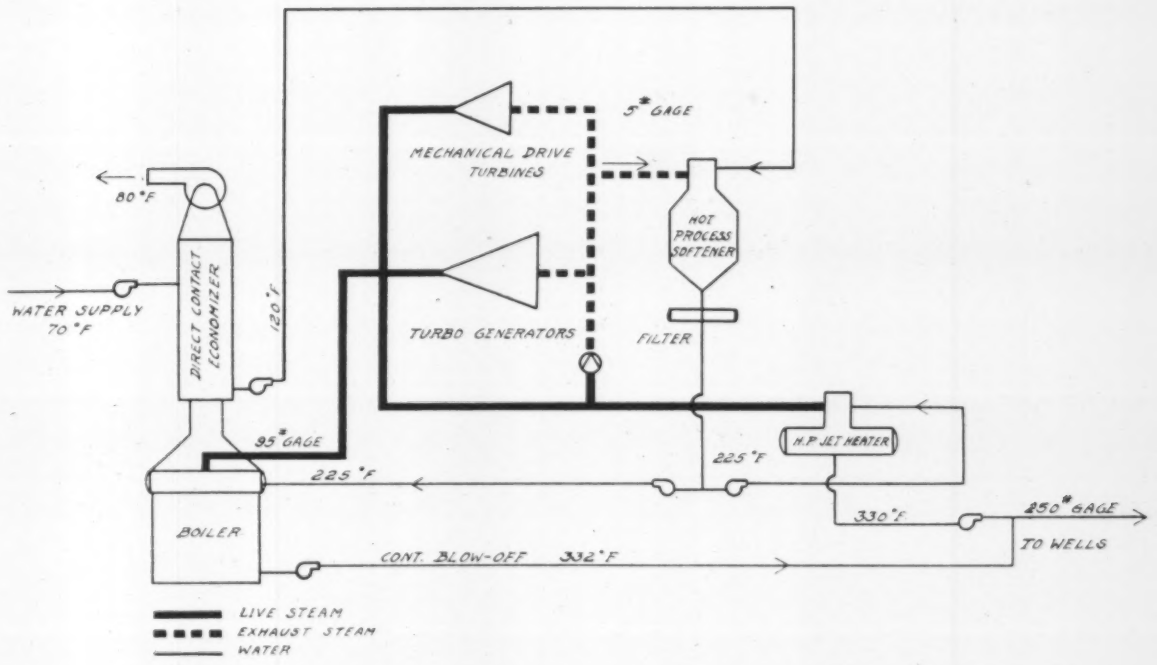


MOST PUMPS USED IN SULPHUR-MINING PLANTS ARE TURBINE-DRIVEN CENTRIFUGALS

centric strings of 6-in., 3-in., and 1-in. pipe. On the bottom of the 6-in. string is a short perforated length which is set at the very bottom of the sulphur-bearing formation. Midway up the perforated length is an orifice through which the end of the 3-in. string will just fit. Thus hot water pumped down the 6-in. pipe must leave through the upper half of the perforations. Sulphur melts at 240 F, and it has been found by experience that the temperature of the entering water should be from 310 to 340 F. Melted sulphur flows through the lower half of the perforations and up the 3-in. line half way to the surface, the



MINE-WATER HEATERS AND PIPING—THE MORE IMPORTANT PIPING IS IN DUPLICATE



DIAGRAMMATIC SKETCH SHOWING PRINCIPAL EQUIPMENT AND FLOW OF STEAM AND WATER THROUGH A SULPHUR-MINING POWER PLANT

specific gravity of molten sulphur being about twice that of water. The 1-in. line inside the 3-in. discharges compressed air which provides an air lift and carries the sulphur to the surface. This process produces sulphur with a purity of more than 99½ per cent.

On the surface the sulphur is pumped by means of centrifugal pumps through steam-gutted pipe lines to the storage vats. These are wooden structures built up as sulphur is discharged and serve only to confine it until it is frozen. When the vat is filled, the wooden forms are torn off, and the sulphur is blasted down and shipped.

At most of the mines, the caprock collapses when sulphur is removed and subsidence takes place. While this is a gradual movement, unaccompanied by shocks, it becomes imperative to lay all surface pipe lines with very generous provisions for the movement of supports and anchorages. Plants and other permanent buildings are located well off the deposits. Because of corrosion, subsidence, and exhaustion of area, the wells are generally short lived, and new ones are continually being drilled.

POWER AND HEATING REQUIREMENTS

Water supply is the first problem in sulphur mining and is obtained from wells, from rivers, or from both these sources. As the water is used but once, enormous quantities are required. In order to obtain a supply of softer water, it is sometimes pumped from rivers during freshets and stored in large impounding reservoirs. Before it is used the water must be softened to prevent the deposit of solids in boilers, heaters, and pipe lines leading from the plant to the wells. Inasmuch as it may be necessary to heat several millions of gallons of water daily, the deposition of only a grain of scale per gallon of water would soon plug the pipe lines. At some plants, water is treated by the cold lime-and-soda process, pumped through a sedimentation basin, and then filtered. At others, it is given a hot-process lime-and-soda treatment followed by sedimentation and filtration. All the water is heated by exhaust steam from pumps and other auxiliaries, and a part of it, generally in the neighborhood of 25 per cent, is used for boiler feed. This is often given a more intensive treatment than the remainder.

The remainder of the water, henceforth designated as mine water, is then heated to the final temperature, say 330 F, in open heaters of the jet type using live steam direct from the boilers at about 95 lb per sq in. gage. This water is then pumped through well-insulated lines to the wells. Practically all pumping is done by high-speed turbine-driven centrifugal pumps.

As nearly all the boiler feedwater is make-up, considerable blowoff is required to prevent excessive concentration of solids in the boiler. This is accomplished by continuous blowdown into the mine-water system. Thus, there are no losses quite regardless of the quantity of blowdown which is necessary.

Sulphur-mining power plants have turbogenerators for supplying power for water-supply pumping, sulphur pumping above ground, and other miscellaneous uses. Large air compressors, generally of the three-stage duplex type, supply air for sulphur pumping. Low-pressure compressors supply air for the operation of tools, for cleaning, and for the washing of filter beds. From 5 to 10 per cent of the total steam generated is used for jacketing sulphur lines and equipment to prevent freezing en route from well to vat.

To date, no plants generate steam at high pressure and reduce it to the water-heating pressure through turbogenerators in spite of the attractive possibilities of the method. There have been two reasons for this: First, until lately the art of conditioning boiler water was not sufficiently advanced to allow high-pressure boilers to be pushed at high ratings with feedwater composed of nearly 100 per cent make-up; and second, a market for the power so generated is not available. The first problem has about been solved, the second is economic in nature and always will be.

After the mine water has been utilized in melting sulphur and heating up the formation, it is brought to the surface in bleed wells, the coldest water in the dome generally being

evacuated. At some mines this water has reached temperatures of from 150 to 175 F. It is heavily charged with sulphide and is almost saturated with salt. It is also highly corrosive, but in spite of all this has been used in preheating the fresh-water supply entering the plant. Because of its corrosiveness it is pumped through cast-iron, or preferably wood, pipe from bleed well to plant and there put through counterflow heat exchangers built of certain bronzes which are highly resistant to its corrosive action.

HEAT-RECOVERY DEVICES

Most of the sulphur mines are located in sections of the country where natural gas is used for fuel. This natural gas is practically pure methane which burns so that 1 lb of methane and 4 lb of oxygen provide 2.75 lb of carbon dioxide and 2.25 lb of water. In other words, for every 1000 cu ft of gas burned 100 lb of water vapor is formed. This water vapor goes up the chimney with the flue gas in the form of superheated steam. By passing the flue gas through a chamber and forcing it to come in contact with fine drops or thin films of cold water, part of this steam can be condensed and the latent heat recovered. The dew point of this gas is about 135 F, so as much cold water as is available must be used.

The heat in the dry chimney gases is also recovered but as compared with that in the water vapor it does not have the same relative importance that it has with other fuels. With adequate contact and counterflow the flue gas may be cooled to within a few degrees of the water entering the plant, and which is thereby heated some 50 F. In this way more than 95 per cent of the higher heating value of the fuel may be recovered. The recovery in winter with cold water is materially greater than it is in summer when the temperature of the water stored in reservoirs may approach 90 F.

This heat-recovery process is hardly applicable in the ordinary boiler plant burning natural gas, as the boiler feedwater alone is insufficient for complete condensation. Also, the conventional power-generation plant has more heat below 135 F than can be utilized.

The water is pumped direct from the heat-recovery chamber, generally called a direct-contact economizer or heat exchanger, to an exhaust heater. There the carbon dioxide absorbed by the flue gas is driven off by heat or is converted to insoluble calcium carbonate by the addition of lime.

These direct-contact economizers have been built in several forms, utilizing different methods of transfer. Vertical tanks have been packed with coke, and the water distributed over the top has been allowed to trickle down as flue gas is discharged upward through the bed. Tanks filled with horizontal screens have also been used and in some cases hurdles similar to those used in a forced-draft cooling tower have been tried. Designs of other types have used horizontal tanks into which water is sprayed in fine drops. These tanks have been baffled and the water sprayed successively into the sections in a path opposite to that of the gas flow. Each type of economizer has its advantages and its defects.

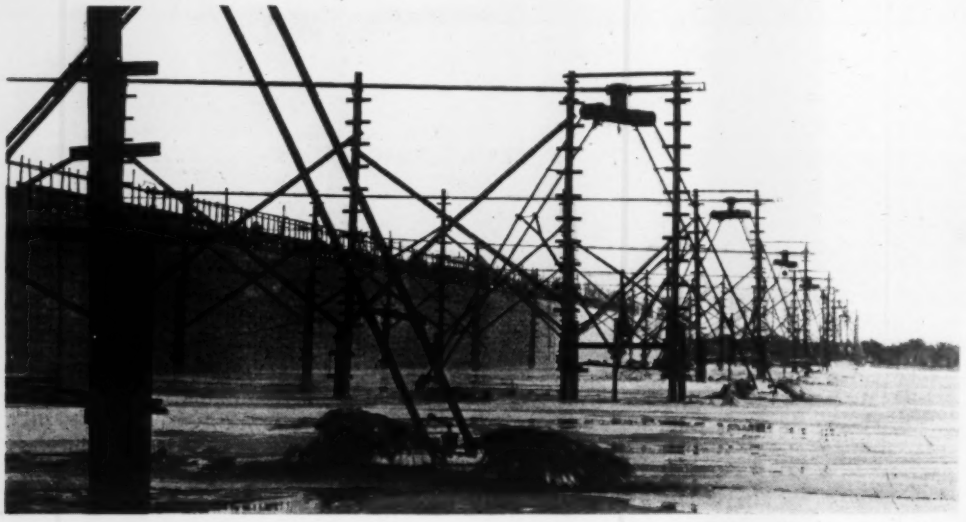
INSULATION OF PIPING

Another problem in a sulphur-mining plant, probably second in importance to water supply and treatment, is insulation. Hot water and steam lines of large size may be several miles long and a loss of 2.5 F in the hot-water temperature represents the loss of 1 per cent in fuel. The ordinary commercial types of insulation are used but the insulation is generally thicker than is customary in the average power plant. As all the mines are in the area which is visited by West Indian hurricanes, a substantial metal covering is generally applied over the insulation.

SPECIAL PROBLEM OF OPERATION

The sulphur-mining process requires enormous quantities of hot water, fuel, and compressed air. The gulf-coast plants soften, heat to more than 310 F, and pump into the ground sufficient water to supply a city with a population of 250,000. One boiler plant can burn a quarter of a million tons of natural gas per year, and to burn this quantity of gas with good combustion requires four and one-half million tons, or a cubic mile, of air.

A sulphur-mining power plant must be designed for extreme reliability, as a shutdown would freeze sulphur in wells, pipe lines, and pumps. Sulphur is a poor conductor of heat and the thawing-out process is both slow and costly. All heating and pumping equipment must therefore be in multiple and all pipe lines in duplicate. With gas fuel, emergency oil-burning equipment is installed so that a gas-line failure will result in only a momentary interruption of the plant's services.



MOLTEN SULPHUR DISCHARGING INTO VAT

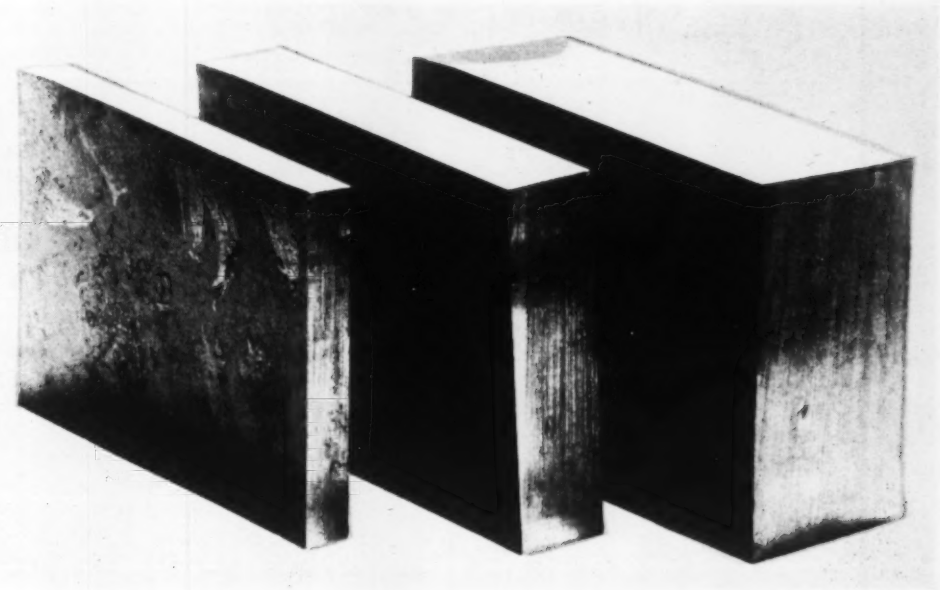


FIG. 1 THREE OF THE HARDNESS-TEST SPECIMENS SHOWING THE TAPER-GROUND SURFACE STUDIED

FLAME-CUTTING STEEL PLATE

Further Studies of the Effects of Oxyacetylene Cutting on Hardness, Structure, and Ductility

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IN A report to the 35th Annual Convention of the International Acetylene Association the author presented the results of certain comparative tests conducted to determine the relative effect of five cutting procedures on the metal adjacent to the cut surface. The cutting methods involved were machining, shearing, friction-sawing, hand-torch cutting, and machine flame cutting, and the general conclusions drawn from this preliminary study were to the effect that any modifications of the base metal due to use of the flame-cutting processes were appreciably less severe than those induced through the use of either shearing or friction-sawing.[1] As the tests from which these conclusions were drawn were all conducted on a $^1/_2$-in. structural plate, the natural next step seemed to be one involving study of the effect of flame cutting on steels other than the A.S.T.M. A9 structural type and of thicknesses other than $^1/_2$ in.

MATERIALS

In selecting the steels to be investigated it was deemed advisable to complete or at least supplement the previous work in the straight low-carbon-steel class. It was further considered advisable in the selection of these steels to choose those having as much variation in metallurgical history as possible in order to determine or point toward any existing relations between steel-making practice and reactions to flame cutting. With these ideas in mind the following four steels were selected:

Type *A* Fully killed open-hearth steel meeting the A.S.T.M. specification A7 bridge-steel requirements.

Type *B* Semikilled open-hearth steel meeting the A.S.T.M. specification A9 building-steel requirements.

Type *C* Semikilled open-hearth steel meeting the A.S.T.M. specification A70 flange-steel requirements.

Type *D* Rimmed open-hearth steel meeting the A.S.T.M. specification A70 flange-steel requirements.

Each of these types of steel was tested in three thicknesses: $^1/_2$, 1, and 2 in. The chemical analyses of the test plates are given in Table 1 and the physical properties in Table 2. The steels conform to the A.S.T.M. test requirements in every case. It should be noted, however, that the carbon range of 0.18–0.23 for the type-*A* and type-*B* test plates is somewhat lower than is frequently to be found in steels supplied under A7 and A9 specifications. It is possible that the data presented and conclusions drawn may not apply precisely to steels of higher carbon which might at the same time conform to these specifications.

[1] "Cutting Structural Steel," by J. H. Zimmerman, MECHANICAL ENGINEERING, July, 1935, pp. 423–427. Slightly abridged.

Presented at the 36th Annual Convention, International Acetylene Association, Cleveland, Nov. 12–15, 1935.

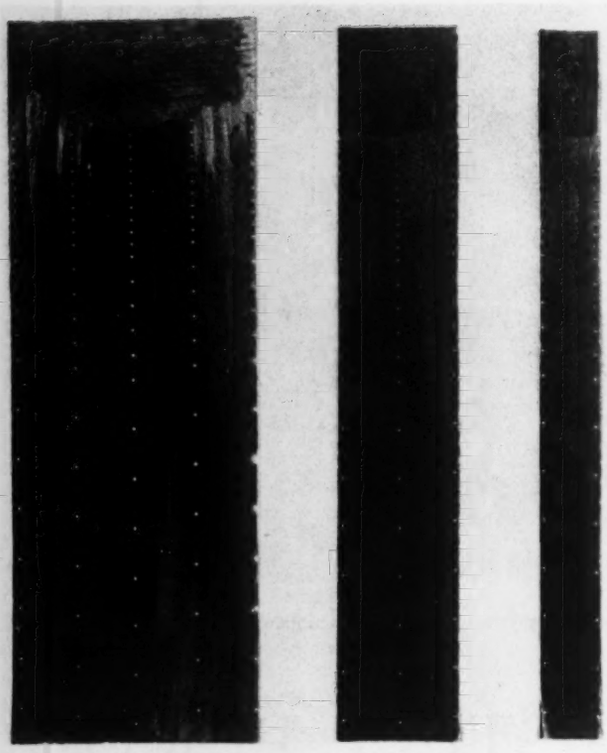

FIG. 2 THE THREE SPECIMENS SHOWN IN FIG. 1 ARRANGED TO SHOW THE HARDNESS-TEST INDENTATIONS

METHOD OF TESTING

In laying out the test program advantage was taken of the experience obtained in connection with the earlier tests referred to. With only a few minor changes the scheme of attack was similar to the one previously employed.

The first step consisted in machine flame cutting the test plates into pieces from which test specimens could be prepared. In each case preliminary test cutting was conducted until a smooth flat cut was produced. This procedure was then carefully followed in producing the test surfaces. All test specimens were removed from fairly massive pieces of plate by machining so that the metal near the flame-cut surface could not have been influenced by any secondary heating effects or other superimpositions.

TABLE 1 CHEMICAL ANALYSES OF THE TEST PLATES

(All values reported are from the slab analyses of the Carnegie Steel Company except Si determinations which were made in the M.I.T. laboratories)

Plate type and thickness	Chemical Analyses C	Mn	P	S	Si
Killed Open-Hearth Plates					
A-1/2	0.20	0.50	0.018	0.047	0.108
A-1	0.19	0.50	0.016	0.040	0.084
A-2	0.21	0.52	0.028	0.041	0.084
Semikilled Open-Hearth Plates					
B-1/2	0.23	0.57	0.023	0.040	0.028
B-1	0.20	0.36	0.029	0.025	0.028
B-2	0.18	0.50	0.028	0.046	0.042
Semikilled Open-Hearth Flange-Quality Plates					
C-1/2, 1, 2	0.16	0.50	0.025	0.030	0.028
Rimmed Open-Hearth Flange-Quality Plates					
D-1/2, 1, 2	0.23	0.52	0.017	0.034	0.047

TABLE 2 PHYSICAL PROPERTIES OF THE FOUR TEST PLATES AS REPORTED IN THE CARNEGIE STEEL COMPANY SLAB-INSPECTION SHEETS

Plate type and thickness	Yield point, lb per sq in.	Tensile strength, lb per sq in.	Elongation in 8 in., per cent	180-Deg cold-bend test
Killed Open-Hearth Test Plates				
A-1/2	47,320	65,020	24.2	O.K.
A-1	40,950	60,340	28.0	O.K.
A-2	39,150	65,520	27.0	O.K.
Semikilled Open-Hearth Test Plates				
B-1/2	37,080	66,340	24.0	O.K.
B-1	42,030	63,840	26.2	O.K.
B-2	45,200	67,460	24.5	O.K.
Semikilled Open-Hearth Flange-Quality Test Plates				
C-1/2	36,400	60,100	28.7	O.K.
C-1	36,040	63,240	27.5	O.K.
C-2	36,720	64,740	30.0	O.K.
Rimmed Open-Hearth Flange-Quality Test Plates				
D-1/2	40,620	59,590	28.7	O.K.
D-1	34,960	60,870	26.2	O.K.
D-2	36,120	58,600	31.0	O.K.

The test schedule adopted as sufficient to bring out any important differences in the reactions of the 12 test plates to machine flame cutting involved (1) hardness tests, (2) macrostructure and microstructure study and (3) bend tests, each of which is to be discussed separately.

HARDNESS SURVEY TESTS

In flame-cutting steel the metal near the cut surface is subjected to an extremely steep temperature gradient, particularly in automatic cutting. The heat carried to the thin layer of metal close to the cut is quickly dissipated into the adjacent cold plate metal and the hardness test has been used to study comparatively the effect of this "metal-quenching" action. The type of test specimen employed in this testing is shown in Fig. 1. The specimen includes the full plate thickness, and a residue of the original flame-cut surface is to be seen at the rear of the top surface in this illustration. The original test surface has been, with the exception of this small area, removed by taper grinding. With the 1-in-25 tapered surface it was found possible to study hardness gradients using very small depth increments. By successive tests every 0.050 in. along the tapered surface, for example, tests were actually made at increments of 0.002 in. from the original flame-cut surface. A survey of the entire test surface actually involved study of the thin layer of metal immediately next to the cut for the full width of the plate. Surveys were made at the top and bottom of the cut and, in the case of the thicker plates, at intermediate stations as illustrated by Fig. 2 in which the specimens were illuminated in such a way as to catch a reflection from each test impression.

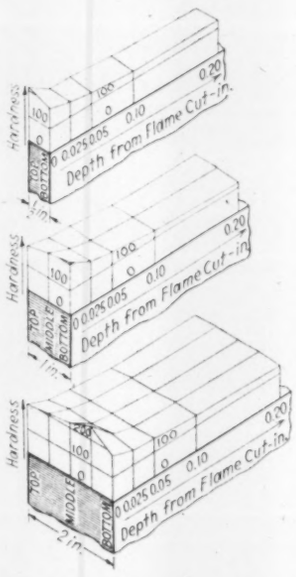

FIG. 3 GRAPHICAL REPRESENTATION OF THE GENERAL EFFECT OF MACHINE FLAME CUTTING ON THE HARDNESS OF THE THREE TEST-PLATE THICKNESSES

The Vickers hardness-test-

ing machine was used for all tests. The method involved the forcing of a four-sided diamond pyramid into the test surface with a dead load of only 30 kg. Accurate determination of the relative hardnesses was obtained by precise measurements of the very small impressions produced.

In general, no particularly significant difference in the four steel types was found. In order to compare the three thicknesses the results were averaged and condensed to the summary included in Table 3. The average response of the three thicknesses to the quenching action is shown schematically in Fig. 3. It should be noted in connection with this figure that the depth scale is greatly magnified. Minor variations in the three thicknesses will be seen but the hardness gradients do not appear to be unduly severe nor do the hardness values seem excessive when correctly interpreted.

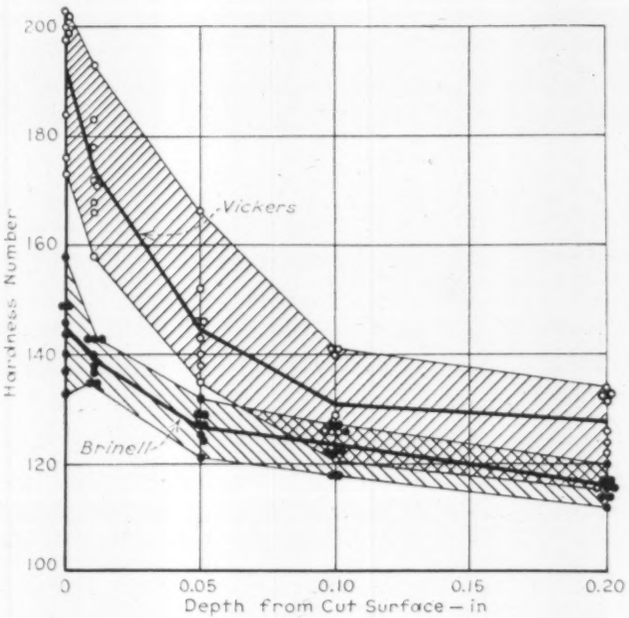

FIG. 4 COMPARISON OF VICKERS AND BRINELL HARDNESS TESTS OF THE FOUR 1-IN. PLATES

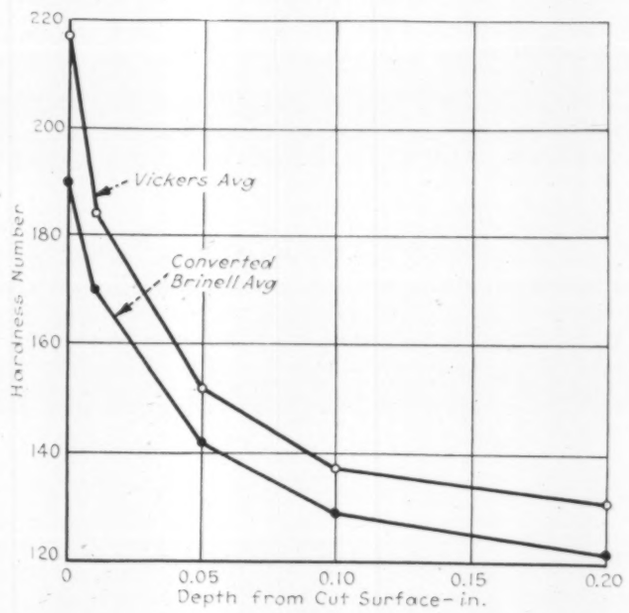

FIG. 5 COMPARISON OF VICKERS HARDNESS NUMBERS WITH BRINELL VALUES OBTAINED BY CONVERTING THE ROCKWELL "B" TEST USING THE BUREAU OF STANDARDS FORMULA

BRINELL = $7300/(130 - R_b)$

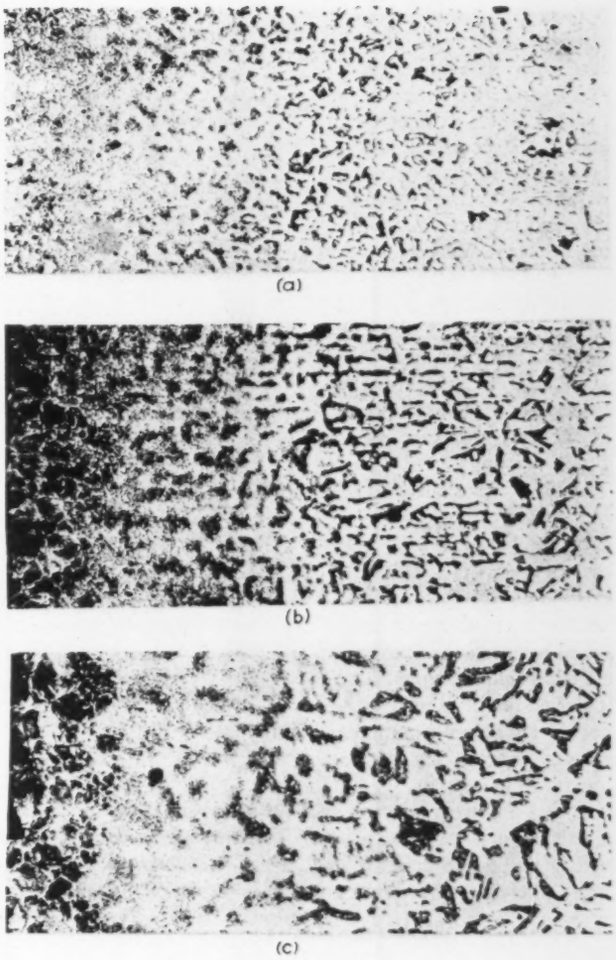

FIG. 6 STRUCTURES OF THE $^1/_2$- (*a*), 1- (*b*), AND 2-IN. (*c*) PLATES (Type-*D* test plates at the flame-cut edge showing an increase in the thickness of the affected metal with increasing plate thickness. ×100 in original, reduced.)

The hardness numbers reported are not to be confused with Brinell hardnesses at the points indicated. In order to clarify physical conception of the local hardening effects, parallel tests employing the more commonly used Brinell and Rockwell hardness testers were conducted. The results of these tests are shown in summarized form in Figs. 4 and 5. The four 1-in. plates were used in making the Vickers-Brinell comparison.

With the standard Brinell test employing a 3000-kg load on a

TABLE 3 COMPARATIVE AVERAGES OF VICKERS 30-KG HARDNESS TESTS OF THE FOUR TEST PLATES AT THE DEPTHS AND SECTIONS INDICATED

Plate thickness and section tested	Depth from flame-cut surface, in. 0	0.025	0.05	0.10	0.20
2 in. top	195	159	148	128	127
2 in. $^1/_2$ in. down	204	170	151	138	131
2 in. middle	217	163	151	135	129
2 in. $1^1/_2$ in. down	253	172	158	141	132
2 in. bottom	187	156	145	138	137
1 in. top	171	154	148	132	131
1 in. middle	194	162	142	132	129
1 in. bottom	207	163	147	129	120
$^1/_2$ in. top	214	161	159	143	130
$^1/_2$ in. bottom	180	158	144	134	132

10-mm ball, two sets of impressions were made on each plate, one row at a depth of $^1/_4$ in. and the other at a depth of $^3/_4$ in. from the top surface. Each of these test rows was midway between two sets of Vickers indentations and the averages of the two adjacent Vickers numbers are plotted with the corresponding Brinell hardness in Fig. 4. The spread of the Vickers readings may be taken as a measure of the sensitivity of the test and the generally higher order of the readings is obvious. For the Vickers-Rockwell comparison the four 2-in. plates were used and four rows of Rockwell "B" scale tests using the $^1/_{16}$-in. ball and 100-kg load were evenly spaced between the five rows of Vickers indentations. The Rockwell readings were converted[2] to Brinell numbers and the average results are shown in Fig. 5.

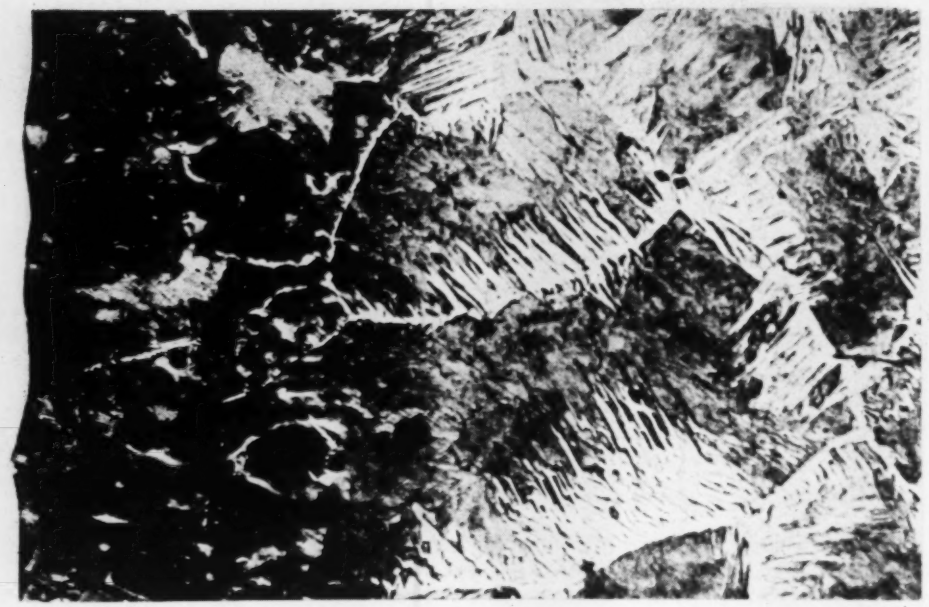

FIG. 8 MICROSTRUCTURE OF THE CUT EDGE IN FIG. 6c AT HIGHER MAGNIFICATION (×300 in original, reduced.)

At this point it is well to recall that earlier work with steels of this type has shown the surface-hardening effect of flame cutting to be appreciably less drastic than the corresponding effects of either shearing or friction sawing.

STRUCTURAL STUDIES

The macrostructure, established by deep-etching a polished transverse surface including the cut edge for the full plate thickness, has been used to bring out comparatively the heat effects accompanying flame cutting of the 12 test plates. The macro-etches disclosed a thin layer of affected metal under each cut. It was noted in this respect that again there was no outstanding difference in the appearance of the four types of plate. The depth of the effect was only a few hundredths of an inch, in any case, with only slightly increased penetration as the plate thickness was multiplied.

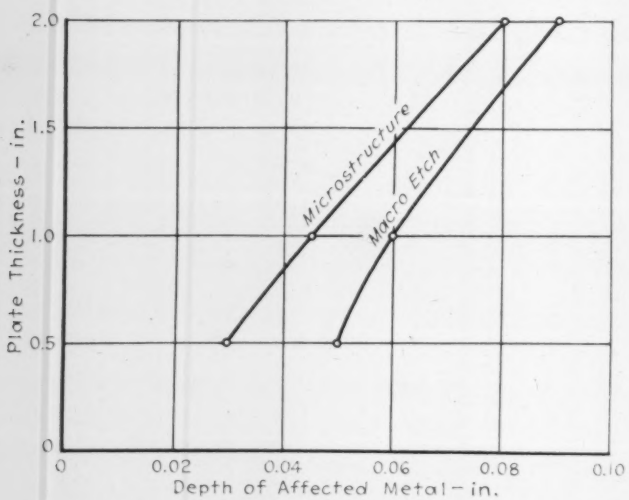

FIG. 7 RELATION BETWEEN PLATE THICKNESS AND DEPTH OF THE DISTURBED ZONE AS ESTIMATED AND AVERAGED FROM THE FOUR TEST-PLATE TYPES

Representative transverse sections from each of the test plates were prepared for microscopic study. This preparation included the mounting of each specimen in bakelite in order to accurately preserve and prevent rounding of the cut surface edge during subsequent grinding and polishing. Examination of these specimens disclosed no important differences in the structural changes in the four plate types.

Representative photomicrographs taken from the three sizes of the type-*D* steel are shown in Fig. 6. These may be considered to be representative of the general appearance of all of the specimens with the exception that there is a slight increase of the affected region in the top and bottom corners of each cut due to slower quenching action. It will be noticed that the depth of the modified structure is increased with plate thickness, but again it should be emphasized that the penetration of structural change was found to increase at a rate very much less than that of direct proportion to the plate thickness. In order to bring this point out the depth of modification in each of the test specimens was estimated, and the average results, together with similar values determined from the macro-etches, are shown graphically in Fig. 7.

The structural changes accompanying flame cutting of these steels were found to be quite gradual. As will be noted in Fig. 6 one structure was found to fade into another and so on until normal plate metal was reached. Typical of the interesting structures observed during the metallographic study of these cuts are those illustrated in Figs. 8 and 9. These show the enlarged structure at the extreme surface of a cut and a higher magnification of the blurred region of Fig. 6c.

In connection with this consideration of the actual structural

[2] "Relationships Between Rockwell and Brinell Numbers," by S. Petrenko, U. S. Bureau of Standards, *Journal of Research*, vol. 5, no. 1, July, 1930, pp. 19–50.

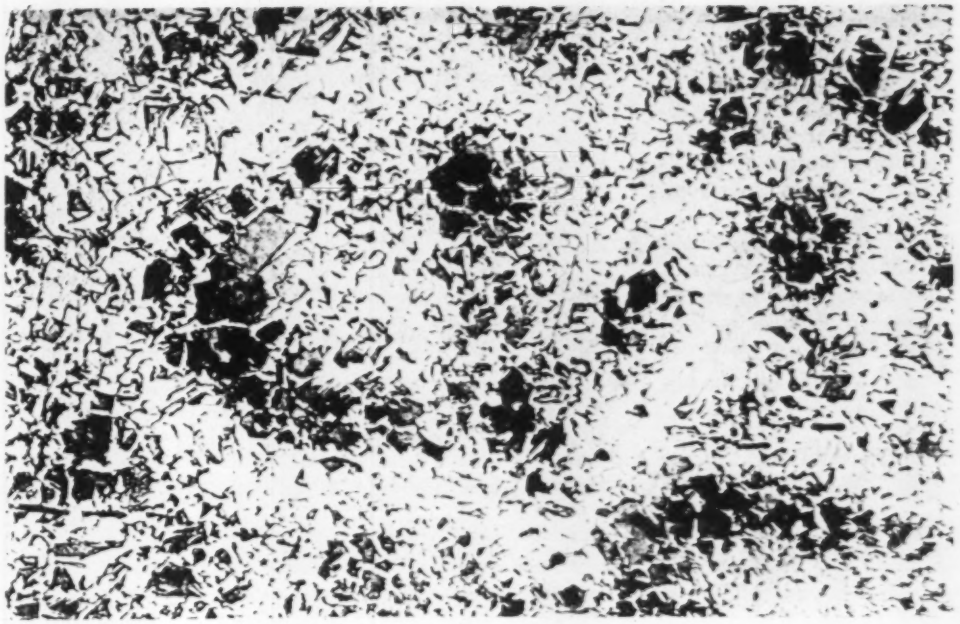

FIG. 9 STRUCTURE OF THE INTERMEDIATE ZONE OF PEARLITE SPREAD SHOWN IN FIG. 6c (×300 in original reduced.)

modifications caused by flame cutting, which have been found to be restricted to a narrow zone of metal near the cut surface, it is desired to point out a common misconception. In Fig. 10 are shown the typical color bands or heat effects, appearing on the top surface of the flame-cut plates. These bands are frequently considered to be representative of the extent to which the metal near the flame cut has been "burned" or damaged. This is definitely not so. This color effect was found to be merely a surface phenomenon having no relation with any physical or metallurgical modifications of the metal adjacent to the flame-cut surface. Toward classification of this misconception Table 4 has been prepared.

In line with the foregoing discussion it would seem in order to quote the following from the A.S.M.E. Power Boiler Code:

Par. 257*a*. The calking edges of plates, butt straps, and heads, shall be beveled to an angle not sharper than 70 deg to the plane of the plate, and as near thereto as practicable. Every portion of the unfinished surfaces of the calking edges of plates, butt straps, and heads shall be planed, milled, or chipped to a depth of not less than one fourth of the thickness of the material, but in no case less than $^1/_8$ in.

Certainly the data reported here show no need for removal of one fourth the thickness of a flame-cut plate in order to bare a metallurgically satisfactory surface for calking. In fact, with the flange steel tested there appears to be no physical nor metallurgical reason why a mechanically smooth, flat, and sharp-cornered flame-cut surface should not be satisfactory for calking without further treatment.

COLD-BEND TESTS

In order further to investigate the comparative behavior of the 12 test plates, a series of bend tests was arranged. Here, as before, the specimens were carefully machined from large flame-cut plates in order to avoid any extraneous effects. The standard $^1/_2 \times 1 \times 7$-in. bend specimen was used in what might be described best as a "corner ductility" test. Specimens were removed from the test plates with one $^1/_2$-in. face in the flame-cut condition. With the specimen bent around a pin normal to this face, one unrounded corner of the test surface

TABLE 4 ESTIMATES OF THE DEPTH OF APPARENT MODIFICATION DUE TO FLAME CUTTING AS AVERAGED FROM THE FOUR TEST-PLATE TYPES

Plate thickness, in.	Depth of modified metal as estimated by		
	Surface color	Macroetch	Microstructure
$^1/_2$	0.30	0.05	0.030
1	0.46	0.06	0.043
2	0.50	0.09	0.080

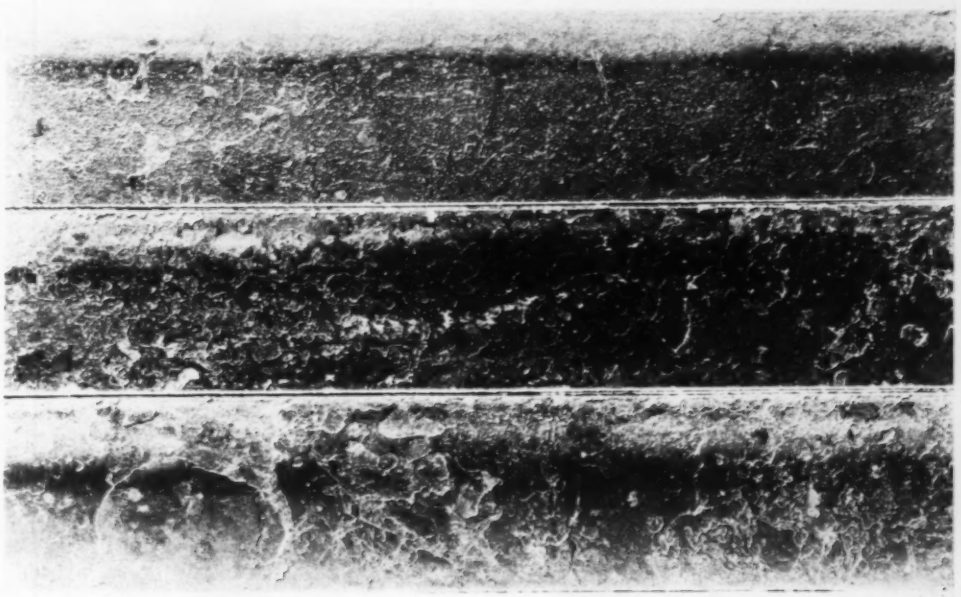

FIG. 10 COLOR BANDS ON THE TOP SURFACE OF FLAME-CUT PLATES

was subjected to the severe stretching action occurring at the outside corners. Both top and bottom corners of specimens from each plate were so tested with the addition of an extra specimen from the middle of the 2-in. plates. After bending 180 deg cold around a pin the diameter of which was as described by the A.S.T.M. specification for the steel in question, the bent specimens were flattened between compression heads until corner cracking occurred or until the specimen was completely flat.

The results of these bend tests are given in Table 5 and the bent specimens are shown in Fig. 11. All specimens withstood the A.S.T.M. bend requirement and most of the specimens bent 180 deg flat, which is evidence of really excellent ductility considering that the corners of the specimens were not rounded off as is permitted in this test.

TABLE 5 RESULT OF CORNER DUCTILITY TESTS USING STANDARD $1/2 \times 1 \times 7$-IN. BEND SPECIMENS WITH ONE $1/2$ IN. SURFACE AS REMOVED FROM FLAME-CUT PLATE

(All other surfaces were machined. The corners of the test surface were not rounded.)

			180 deg cold-bend test		
Plate type	Plate thickness, in.	Part of cut at outside of bend	A.S.T.M. spec. pin diam, in.	Final diam, in.	Condition of test surface
A	1/2	Top	1/4	0	No cracking
A	1/2	Bottom	1/4	0	No cracking
A	1	Top	1/2	0	No cracking
A	1	Bottom	1/2	0	No cracking
A	2	Top	1 1/4	0	No cracking
A	2	Middle	1 1/4	3/8	Cracked
A	2	Bottom	1 1/4	1/8	Cracked
B	1/2	Top	1/2	0	No cracking
B	1/2	Bottom	1/2	0	No cracking
B	1	Top	3/4	0	No cracking
B	1	Bottom	3/4	0	No cracking
B	2	Top	1 1/4	0	No cracking
B	2	Middle	1 1/4	0	No cracking
B	2	Bottom	1 1/4	1	Cracked
C	1/2	Top	1/2	0	No cracking
C	1/2	Bottom	1/2	0	No cracking
C	1	Top	1/2	0	No cracking
C	1	Bottom	1/2	0	No cracking
C	2	Top	1	0	No cracking
C	2	Middle	1	0	No cracking
C	2	Bottom	1	0	No cracking
D	1/2	Top	1/2	0	No cracking
D	1/2	Bottom	1/2	0	No cracking
D	1	Top	1/2	0	No cracking
D	1	Bottom	1/2	0	No cracking
D	2	Top	1	0	No cracking
D	2	Middle	1	0	No cracking
D	2	Bottom	1	0	No cracking

SUMMARY

Hardness surveys, structural studies, and bend tests have been conducted on three thicknesses each of four steel types selected from the low-carbon class.

In general, the four steels have been found to react to the machine-flame-cutting process in an essentially similar manner and increased plate thicknesses have been found to be accompanied by relatively small increases in the modification of the metal adjacent to the cut surface.

ACKNOWLEDGMENT

The author wishes to acknowledge with thanks the very kind cooperation of the United States Steel Corporation and the Carnegie Steel Company who supplied the steels used in these tests.

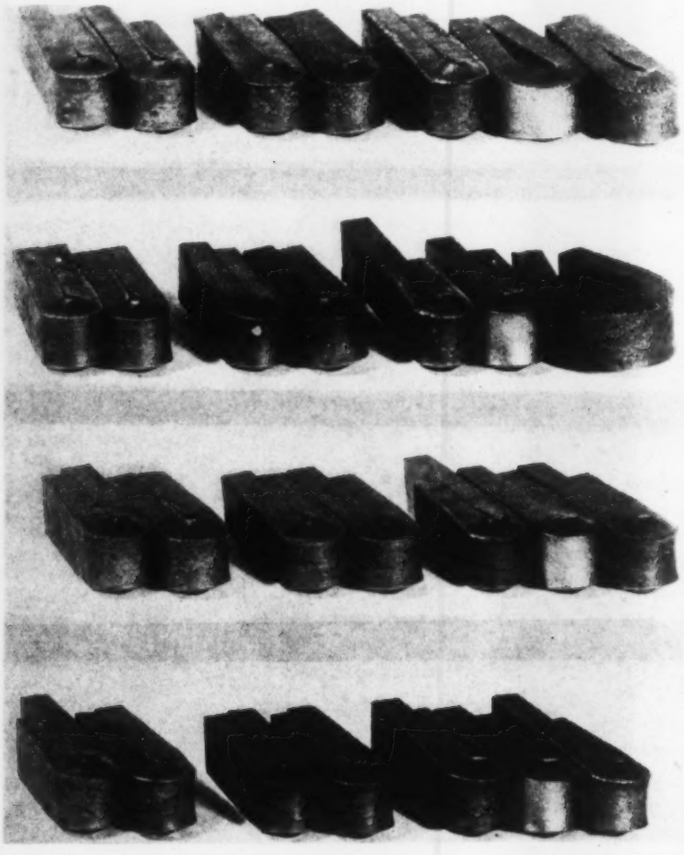

FIG. 11 CORNER-DUCTILITY BEND-TEST SPECIMENS WITH FLAME-CUT SURFACE AT TOP

AIR CONDITIONING *by the* SUN

A Study of the Possibility of Using Solar Energy for Air Conditioning in Florida

By WILSON P. GREEN

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SCIENTIFIC measurements show that more than 0.16 hp or 430 Btu per hr reaches every square foot of the earth's atmosphere. While part of this is absorbed in the atmosphere by dust or moisture, actual experiments have shown that from 100 Btu to as high as 223 Btu per hr can be obtained from each square foot of surface exposed to the sun's rays. The equivalent of 100 Btu per hr per sq ft is 1/25 hp per sq ft. Thus a small 50 × 20-ft building with a roof area of 1000 sq ft exposed to sunlight absorbs at least 100,000 Btu per hr, or the equivalent of 40 hp. This is almost enough heat to operate refrigeration equipment in the summer and heating equipment in the winter for air conditioning the building. However, at the present time little successful work has been done toward using the energy of the sun effectively, since its intensity, while great enough to cause discomfort in summer, is so low that ordinary sunlight will not furnish a source of power for air conditioning.

If we attempt to use the sunlight or radiant solar energy for air conditioning residences we are immediately confronted with several difficult problems. First, we must secure enough radiant solar energy to operate the cooling or heating plant and then concentrate this energy in order to secure a temperature high enough to make it of value. Second, we must make some provision for storing enough of the energy to operate the air-conditioning plant during periods when the sun is obscured by clouds and for several hours at night after the sun has set. Third, we must adapt the solar generator or energy collector to the conditions of operation of present types of air-conditioning equipment or devise new equipment to meet the operating characteristics of the generator. Finally, the cost of the solar-energy plant must be low enough to compete with other types of equipment for air conditioning.

Since the type of equipment chosen to meet the first condition, namely, the securing of enough radiant solar energy and the concentrating of this energy at high enough temperatures, will depend upon the size of the plant necessary to collect sufficient energy, a preliminary estimate of the size will be made before going further. For an ordinary eight-room Florida residence about five tons of refrigeration will be required for proper air conditioning of the entire house under maximum-load conditions. With proper insulation of the building walls and careful zoning of the most used portions of the house throughout the day it is possible to reduce this figure to around two tons of refrigeration. However, since this type of construction is expensive the more conservative figure of five tons or 60,000 Btu of refrigeration per hour will be used. As an efficiency of 33 per cent or better can be expected from heat-operated refrigeration units, then a solar-energy collector and concentrator will be required of such a size as to supply 180,000 Btu per hr under maximum-load conditions. Such a plant will necessarily be a large one, since in other locations heat-collection values of 125 Btu per sq ft of exposed surface have seldom been exceeded. Using this value, at least 1440 sq ft of surface must be covered by the energy collector.

Both the steam-jet and absorption systems of refrigeration, as well as the newer systems, require operating temperatures in the neighborhood of 250 F, so that a rather high concentration of rays must be made to secure this heat intensity. Thus the collector and concentrator must necessarily be large and of high concentrating capacity. Practically all important engineering work available in this line was reviewed in order to see what had been accomplished. From this review, the most important methods previously used to concentrate and collect solar energy will be briefly considered.

METHODS OF COLLECTING AND CONCENTRATING SOLAR ENERGY

The average person would probably think of using the magnifying glass or lens as the first method of collecting and concentrating solar energy at temperatures high enough to make it usable, since all are familiar with the high temperatures which can be secured with the "burning glass." But the size of a lens is so small that not enough heat is collected to be of value as a source of power, although very high temperatures are obtained by concentrating the energy obtained upon a point or very small area. A recent use of the lens for concentrating solar energy has been made by the California Institute of Technology in constructing a huge solar furnace by using 30 lenses to focus the sun's rays from a circular area 15 ft in diameter upon a small spot. The temperature secured is around 6000 C or 10,832 F on a clear day and melts steel wire as if it were butter. On account of the expense of securing a lens or a group of lenses large enough to give any quantity of power and the heavy weight of such equipment it would be impractical to use this method for air conditioning.

The collector of solar energy most commonly used today is called the solar "hot box" from the first model which was a box covered with glass, insulated, and painted black inside. Present modifications of this type are used in Florida and California for domestic water heaters, particularly in southern portions of these states. Temperatures as high as 240 F have been obtained in this type of heater in Arizona and other very favorable locations, but temperatures in excess of 180 F are seldom secured unless an expensive type of construction with heavily insulated walls and double glass cover is used.

As early as 1902, H. E. Willsie, American engineer, built a binary-vapor pumping plant run by this type of collector. He circulated water through a rectangular glass-covered heater and stored the heated water in an insulated tank. This stored hot water was utilized to boil off sulphur dioxide which ran a small pumping engine. His heater or collector had an asphalt bottom, wooden sides, and was covered with glass. On later more efficient collectors he used a double glass cover and tilted the collector so that it was perpendicular to the sun's rays. Several plants, similar to Willsie's, were built

after 1909 by Frank Shuman, Philadelphia engineer. This type of solar-energy collector has a comparatively low cost and is easily built into a sloping roof or constructed upon the ground. However, it collects heat at only low temperatures (100 to 180 F) and is efficient only during the middle of the day, since it is stationary and cannot follow the sun in its daily motion.

EARLY ATTEMPTS TO UTILIZE SOLAR ENERGY

Probably the oldest method of collecting solar energy at high temperatures was by concentrating the rays of the sun upon a surface by means of mirrors. Archimedes is said to have used this method as early as 214 B.C. to set fire to Roman ships while they were at a considerable distance from the shores of the island of Sicily. In 1878 August Mouchot first generated power from the reflected and concentrated rays of the sun. He used a huge reflector shaped like a lamp shade and lined with burnished silver to reflect and concentrate the sun's rays upon a boiler located at the focal axis of the reflector. By using a large reflector area as compared to boiler area, he was able to get a steam pressure of 75 lb per sq in. (325 F approximately) and run a $^1/_2$-hp engine. The diameter of the conoidal reflector was $8^1/_2$ ft. The noted engineer, John Ericsson, later experimented with this type of equipment, using a parabolic trough lined with small mirrors to reflect the rays of the sun upon a small tubular boiler located along the focal axis of the reflector. He obtained as high as 210 Btu per sq ft of sunshine collected. About 1901 the English inventor, A. G. Eneas, built several reflectors of the truncated-cone type that absorbed as high as 223 Btu per sq ft of sunlight collected at their Arizona locations. In 1913 a successful steam plant using parabolic-trough reflectors which were geared to an engine so as to be kept facing the sun continually was built by Frank Shuman and Professor Boys at Meadi, Egypt. This plant develops 50 hp and collects 13,269 sq ft of sunshine. Its first cost was about twice that of an equivalent coal-burning plant and it would compete on an equal basis with a coal-fired plant with a fuel cost not less than $2.36 per ton. The outstanding feature of the mirror-type reflector and concentrator is that high temperatures may be secured by concentrating the energy from a large area upon a very small boiler or absorber. Dr. C. G. Abbot, of the Smithsonian Institution, showed this recently when he attained a temperature of 375 F while circulating oil through a $1^1/_2$-in. pipe at the focus of a $7^1/_2$ by 12-ft parabolic reflector. The use of glass mirrors for reflectors made the apparatus expensive but the cost may be decreased by using aluminum or some other polished metal for the reflector material.

TYPES OF HEAT-OPERATED REFRIGERATION PLANTS

For operation by heat there are at present three main types of refrigeration plants that will be useful for air conditioning. The ammonia-absorption system is familiar to engineers. For efficient operation it requires a temperature of around 250 F in the generator to boil off the ammonia vapor from the strong ammonia-water solution. Machines built with no moving parts, such as the Electrolux, offer difficulty in construction and require still higher temperatures. The steam-jet type of equipment is well developed at the present time and can be secured in low-pressure models using steam at 2 lb per sq in. gage or higher pressures. This system also requires an operating temperature above 220 F. The silica-gel-sulphur-dioxide adsorption system which uses sulphur dioxide as the refrigerating medium and silica gel as an adsorbing agent requires intermittent heating and cooling of the silica gel and higher temperatures than either of the previously mentioned systems. It does not seem as well fitted to the needs of the problem as do the other two systems for other reasons. Thus, present types of refrigerating equipment make it necessary that the solar-energy collector and concentrator have an operating temperature of at least 250 F and a maximum temperature, dictated by storage considerations, of at least 325 F.

To secure a temperature as high as this without enormous expense the reflector of the parabolic-trough type made of aluminum or some other metal of good reflective characteristics is most practicable. It is much less expensive than a lens-type collector and lighter but more expensive than the "hot-box" type. However, since the hot-box type can be depended upon for temperatures as high as 150 F it could be used as a preheater for steam-jet refrigerating equipment. For the ammonia-absorption system the entire heating unit would have to be of the reflector type since the condensate is withdrawn from the generator at a temperature greater than 150 F.

AN EXPERIMENTAL COLLECTOR DESCRIBED

In order to secure definite information as to how much heat can be expected from a square foot of Florida sunlighted area, a parabolic-trough or cylinder-type heater was built and mounted upon the roof of the engineering shops at the University of Florida, Gainesville, Fla. The reflector has a length of 3 ft and a width of 4 ft and is enclosed in a sheet-metal case insulated inside with a single thickness of celotex. The reflector material is a thin sheet of nickel-plated zinc. The top of the reflector case is covered with ordinary window glass. The collector is turned about an axis, parallel to the earth's axis of rotation, by a system of weights and is timed by two alarm-clock motors so as to be facing the sun continually. At the focus of the reflector inside its case there is a 2-in. round iron pipe which has inside of it a $1^1/_4$-in. pipe. Water circulates by gravity between the two pipes and is heated by the sun's rays which the reflector concentrates upon the pipe. Provision is made for measuring the quantity of water circulating and the temperature rise. Thus the heat absorbed can be calculated. Results obtained during runs in November, 1934 and 1935, showed as high as 128 Btu per sq ft per hr of sunshine collected was possible with this simple type of construction. Radiation losses being less will tend to increase this value during the summer, although the increase in the humidity of the air during the summer cuts down the atmospheric transmission of solar energy. Operating temperatures as high as 220 F were readily obtainable, the aforementioned test being run at 210 F. When filled with water and with all outlets closed, the steam pressure rose to 50 lb per sq in. gage, indicating a temperature in the absorber of approximately 300 F. The ratio of the area of sunshine collected (concentration ratio) to the area of the absorbing surface in this collector is $6^1/_2$ to 1, approximately. Since it is desirable to reach the temperature of 250 F in operation and above 300 F as a maximum, the concentration ratio should be increased to about 11 to 1. This will also increase the operating efficiency of the unit, since the radiating surface of the absorber will be decreased and therefore both radiation and convection losses from this surface cut down. Tests by Dr. Abbot of the Smithsonian Institution have given temperatures of 375 F during operation. He has taken elaborate precautions to prevent losses due to radiation from the absorber by surrounding it with two concentric glass cylinders with a partial vacuum between them.

REQUIREMENTS FOR A SOLAR-ENERGY PLANT

Since the efficiency of the absorption system is about 33 per cent, about three times as much heat will be required to operate the system as the cooling effect obtained. For a

one-ton refrigeration plant removing 12,000 Btu per hr at least 36,000 Btu would be necessary in operation. Since tests have indicated that at least an average value of 100 Btu per sq ft of sunshine collected can be obtained, a reflector surface collecting 360 sq ft of sunshine per ton of refrigeration is indicated. To take care of losses this should be increased to 400 sq ft. Figures for steam-jet-operated plants depend upon the temperature of the condensing water, but would vary little from these values for Florida. With storage a collecting capacity sufficient to supply a four-ton refrigeration plant will meet the occasional maximum-load demands of five tons. The plant for a four-ton refrigeration system would need 1600 sq ft of sunshine collected. This would require a reflector 50 ft long and 32 feet wide. A reflector of this size would be extremely unwieldy and expensive to build, especially if it had to withstand tropical storms. Twenty units each 4 ft wide and 20 ft long could be fabricated much more easily and could be mounted beneath a glass roof of the building to protect them from dirt and wind. It would, however, be necessary for the roof to face the south and slope at an angle equal to the latitude of the location. Using a steam-jet system, 12 per cent of this area could be built in the form of a hot box to be used as a preheater.

Provision for storing the heat collected, or a part of it, so that the plant could remain in operation during cloudy periods and for at least three hours after sunset is another problem to be met in using solar energy for air conditioning. This will mean the storing of hot water or some other heated medium in sufficient quantities to furnish the reserve heat necessary for efficient operation. Insulated storage tanks will make this feasible. If water is stored it will have to be stored under pressure. Oil could be used and stored at atmospheric pressure at high temperatures but because of the fire hazard, low specific heat, and expense, the storage of water at a maximum pressure of 80 lb per sq in. gage is recommended. A storage tank with a capacity of at least 2000 gal will be necessary to meet winter needs for operation during cloudy periods and will allow for operation at night during the summer.

Unless artesian well water is available or city water can be purchased cheaply, it will be desirable to use a cooling tower and recirculate the cooling water through the refrigeration-plant condenser. This procedure will be cheaper in most cases than purchasing cooling water from the city and allowing it to waste after passing through the condenser. The one to two horsepower necessary for driving the circulating pumps, all fans connected to the conditioner system, and the injector or feedwater pump could be secured by drawing off steam from the storage tank to run a small steam engine whose exhaust steam operates the cooling or heating system of the air-conditioning unit. This would, of course, mean that the water in the storage tank would have to be at a higher temperature than would otherwise be required for operating the heating or cooling equipment, but would afford much more efficient use of the heat energy and would only increase the requisite collector area by a small amount. An alternative construction would be to use electric power to drive all auxiliaries with a corresponding increase in the operating cost of the plant.

Since there is about three times as much heat available for heating purposes as the plant will develop for cooling, a solar plant of the type and size mentioned for cooling purposes will furnish more than adequate heat for practically all Florida weather conditions, for the maximum heating load on an eight-room residence will seldom exceed 72,000 Btu per hr. Thus there will be sufficient heat for supplying large quantities of domestic hot water. Heaters of the reflector type are effective during the winter months as atmospheric conditions are better for the transmission of solar energy, although radiation losses are increased and solar radiation drops off slightly. This use of the plant for both heating and cooling will aid in justifying the rather high first cost of the installation.

Limitations of a plant of the size proposed are its large size and rather high first cost. Offsetting these to some extent, however, is the low operating cost unless auxiliaries are driven by electric power. The maintenance cost will be low if the collectors can be located beneath a glass roof or a roof of some glass substitute. However, this construction limits the size of the collector to the amount of available roof area. For the residence discussed it would in most cases be impossible to find 1600 sq ft of roof area that could be used for the solar energy plant.

By a much more expensive construction of the collector units and by insulating the building and zoning the most used portions, it would be possible to bring the size of the required collectors down to the available roof area. This is more readily seen when it is understood that the maximum cooling load could be reduced through zoning and insulation to about two tons of refrigeration. A plant collecting 80,000 Btu would then operate this unit. By also using a glass vacuum tube around the absorbing element and an accurately constructed reflector the effective amount of heat collected could be nearly doubled per square foot of sunshine-collecting area.

However, such refinements would increase the first cost although cutting down the necessary reflector area to about 700 sq ft. The total cost of air conditioning would not be appreciably lowered due to this high first cost. For this reason it does not seem that solar energy offers a solution to the problem of cheaper air conditioning at the present time. It can only be said to be a source of energy which can be efficiently utilized for air conditioning if fuel or power costs increase rapidly or if more efficient collection equipment is discovered which can be manufactured at low cost.

Air-Conditioning in Florida 80 Years Ago

AS George B. Roth reminds us in the May issue of the *Scientific Monthly*, Dr. John Gorrie (1803–1855), of Apalachicola, Fla., on May 6, 1851, was granted the first U. S. patent, No. 8080, on an apparatus for the mechanical production of ice. In the practice of medicine at Apalachicola, Dr. Gorrie became convinced that excessive heat was the greatest obstacle in his fight against fever, and devoted his attention to the air-cooling of rooms in hospitals.

Gorrie wrote: "My whole process consists in first suspending an ornamental mantel vase, urn, or basin, in which the ice is placed, by chains like a lamp or chandelier, from the center of, and close to the ceiling of a room. Next, over this vessel an opening is made in the ceiling from which a pipe is extended, between the ceiling and the floor above, to the chimney of the house . . . through it (chimney) and the pipe, instead of the doors and windows, all the air as far as possible . . . ought to be received. In such an arrangement the external and fresh air is attracted . . . to the upper part of the room, in consequence of the partial vacuum formed around the ice, and hence, after being cooled, it is dismissed in a diffused shower to . . . the floor to be discharged by the lower pipe."

The necessity for large amounts of ice in a country where none was available led Doctor Gorrie to the invention of the ice machine which he patented. The working substance was air, compressed and expanded in suitable cylinders. A model of the machine is on display at the Smithsonian Institution of Washington.

SUSPENDED SOLIDS *in the* FOAMING *and* PRIMING *of* BOILER WATER

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UNTIL 1927 no one seems to have questioned the belief that finely divided solid matter in a boiler water greatly increases the carry over of liquid water into the steam. In that year Joseph and Hancock, two British chemists, published a paper (1)[1] containing quantitative results both with an experimental boiler and with a locomotive boiler. These results showed that under the conditions of the experiments the various kinds of solid matter employed had little or no effect on the priming.[2] In the summary at the end of the paper is this sentence, "The effect on priming of finely divided calcium carbonate or boiler scale is negligible."

This statement was not readily accepted in this country and, so far as the author is aware, is not now accepted by the majority of engineers. Slowly accumulating quantitative research on the subject, however, tends, in part at least, to confirm Joseph and Hancock's conclusion, and it is worthwhile then to examine both sides of the question.

EVIDENCE THAT SOLID MATTER PROMOTES PRIMING

First, what is the evidence for the belief that solid matter promotes priming? There is plenty of it. The experience of ore flotation shows that finely divided solids stabilize foams, and books on colloid chemistry state it as an experimental fact. Bancroft (2) explains the effect by saying that the solids "armor plate" the foam bubbles. Boiler-water chemists, however, offer even more direct evidence in favor of this side of the case. The author (3) published a paper in 1924 in which a long list of experiments is recorded showing the stabilizing effects of finely divided solid matter on the foaming of such salt solutions as appear in steam boilers. These experiments were all made in glass vessels at atmospheric pressure, but it was assumed at that time that the same effects would occur in boilers. In 1929 Eberle (4), who worked with an experimental boiler, stated that suspended solids had more effect than dissolved salts in producing wet steam.

Finally, there is presumptive evidence that in the early days of steam engineering, when boiler pressures were low, suspended solids played a more important rôle than at present in the production of wet steam. Reference will again be made to this point.

In brief, any one who had read the literature of boiler-water chemistry prior to and closely following the appearance of Joseph and Hancock's paper, could have come to only one conclusion, namely, that suspended solids greatly promote wet steam.

EVIDENCE THAT SOLID MATTER DOES NOT PROMOTE PRIMING

Let us turn now to the evidence for the other side of the case. Joseph and Hancock experimented with a cylindrical boiler having a working capacity of 25 liters (6.6 U. S. gal), which they operated at a pressure of from 150 to 155 lb per sq in. The priming of various salt solutions was first determined and then the priming of the solutions of the same salts at the same concentrations but with solid matter added. The added solids were in some experiments finely divided calcium carbonate and in others powdered boiler scale (carbonate and sulphate). In brief, the concentrations of dissolved and suspended matter were measured and were varied independently of each other. In one experiment the solids were produced inside the boiler by pumping calcium-chloride solution into sodium-carbonate solution in the boiler where calcium carbonate was precipitated. This latter experiment showed a little effect, but in the main the investigation amply bore out the statement previously quoted that "The effect on priming of finely divided calcium carbonate or boiler scale is negligible."

Joseph and Hancock also made an experiment with a locomotive boiler, which they report as follows: "Trials with an unsoftened well water (dissolved solids = 800 ppm; total hardness = 30 deg), and with the same water softened to 3 deg showed that priming commenced in each case at practically the same concentration of dissolved solids, i.e., about 3200 ppm." There was, of course, a far heavier precipitation in the boiler when fed with the unsoftened water than was the case when the softened water was used.

In 1930 Hancock (5) repeated many of the experiments made in the previous investigation with Joseph and obtained the same results.

The question was of such importance that the author and one of his students, S. F. Whirl (6), built a boiler at Ohio State as nearly as possible like the one used by Joseph and Hancock and carried out an extensive series of experiments with salt solutions and added solids. Powdered limestone and ground flint were used. The results were the same as those obtained by Joseph and Hancock, when the same conditions were observed. This latter point is significant and will be referred to later.

There is also at least one statement based on a quantitative investigation of the priming of large power-plant boilers. Mumford in 1929 (7) in his studies of the effect of hydroxyl concentration on moisture in steam, made the following statement: "The effect of the critical concentration of hydroxyl has been the same in boilers just filled with raw water as it

[1] Numbers in parentheses refer to the Bibliography at end of paper.

[2] The word "priming" as used in this paper means any carry over of water in the steam.

Contributed by the Joint Research Committee on Boiler Feedwater Studies, and presented at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

was on boilers which had been in the line for weeks, so that the effect of hydroxyl must have been independent of the concentration of suspended matter, which must have varied under the above conditions." The inference here certainly seems to be that suspended matter played a minor rôle.

Finally, advocates of the belief that solids do not always promote priming can point to the fact that in the earlier papers (prior to 1927) few are to be found in which all the conditions are carefully described and taken into account. In at least one case an investigator's zeal blinded him to the effect of an obvious condition in his experiment.

In short, there is a growing amount of evidence in favor of the opinion that suspended solids frequently have little or no effect on priming. How now can these opposite views be brought into line? Are there not some reasons other than faulty observations to account for the situation? The author believes that there are such reasons and offers the following evidence to show that both views may be correct, depending on conditions.

ADDITIONAL EVIDENCE

In repeating the work of Joseph and Hancock the experiments at Ohio State were arranged to test a hypothesis suggested in a paper by Foulk and Hansley (8) who had shown in 1932 that certain solids lost their foam-stabilizing properties on several hours' boiling in a dilute salt solution in an open flask. It was thought that this loss would be more rapid at the higher temperatures of a boiler. The results published in 1934 (6) proved this supposition to be true. The Ohio State Joseph and Hancock boiler was equipped with a device by which the solid matter (ground limestone) could be added after the boiler had reached its operating pressure and temperature. When the experiments were made in this way the solids increased the priming, the effect being especially strong at the lower pressures. However, the priming tendencies were lost in five to ten minutes contact with the hot boiler water, the rate of loss being greater the higher the temperature (pressure).

This rapid loss of foam-stabilizing effect has an important bearing on Joseph and Hancock's experiments which were made by putting the solid material into the cold boiler and then heating it up to pressure. The time required to bring the boiler to a pressure of 150 lb per sq in. was so long and the temperature of the water during a large part of the time was so high, that the solid matter lost its effect.

Not all kinds of solid matter, even if very finely divided, increase the foaming of salt solutions or the throwing of water into the steam lines. It has been shown at Ohio State (6, 8), for example, that ground flint, which is nearly pure silicon dioxide, is such a solid. When put into an experimental boiler at 150 lb pressure it not only did not increase the priming but materially reduced it. Ground flint is, of course, not a compound found in boiler waters, but having discovered that it behaves as it does, one naturally wonders whether some regular boiler solids may not behave the same way. This behavior of ground flint appears to be independent of the temperature.

Experiments have also been made at Ohio State on the effect on foaming of boiler scale containing oil (8). After the oil was extracted, the foam-stabilizing properties were largely lost. These experiments were made in glass flasks. The results are significant because in the early days of reciprocating engines, oil was used in the cylinders and if condensed steam was returned to the boiler, the sludge absorbed oil and thus became a foam stabilizer. The effect on priming, however, depended on the rate at which the sludge took up oil as compared with the rate at which it lost the oil to the hot boiler water.

The effect on priming of solid matter is less at higher than at lower pressures. This is brought out in the paper by Foulk and Whirl (6). The falling off of carry over with increase of pressure is, however, probably not a function of the solid matter. Recent experiments in the author's laboratory show that the carry over of a sodium-chloride solution is materially less at 150 lb than at 250 lb pressure.

Most of the evidence just cited is based on the effect of solid matter added to the boiler water. This is only half of the picture because most of the suspended solids in a boiler are produced in it by chemical precipitation. The effect of solids produced inside a boiler might be quite different from that of solids added from the outside, and therefore an extensive investigation of this point has been carried out in the author's laboratory (9). The work was done in a small water-tube boiler operating at a pressure of 250 lb per sq in. This little boiler is a replica of the one described by Christman, Holmes, and Thompson (10). The following results of the investigation are presented.

That commonest of boiler solids, calcium carbonate, was found to vary in its effect according to the way it is precipitated in the boiler and according to the time of contact with the boiler water. For example, if the calcium carbonate is precipitated by the decomposition of calcium bicarbonate inside a boiler operating at 250 lb pressure (401 F), it decreases the priming of a salt solution. If the carbonate is precipitated by pumping sodium-carbonate solution into a boiler containing calcium chloride, in other words, if the precipitate forms in an excess of calcium chloride, the results are inconclusive. On the other hand if the calcium carbonate is thrown down by pumping calcium-chloride solution into the boiler containing an excess of sodium carbonate the precipitate increases the priming, and if, now, this precipitate which promotes priming is kept in the operating boiler for four or five hours it not only loses its effect as a promoter of priming, it actually reduces the priming. This effect has also been observed by Holmes (11) in the case of sludge precipitated by concentrating a natural water in his experimental boiler. Holmes called the phenomenon "aging of the sludge." It is thus seen that this form of calcium carbonate can increase priming, have no effect on priming or can decrease priming, depending altogether on the length of time it is in contact with the hot boiler water.

Magnesium hydroxide, also a common precipitate in a boiler, was shown to reduce priming, and if thrown down in sufficient quantity along with that form of calcium carbonate which increases priming, it counteracts the effect of the carbonate, so that by selecting different ratios of carbonate and hydroxide one can have a positive or negative effect, or no effect at all on the priming of the salt solution in the boiler.

GUIDING PRINCIPLE OF SMALL-SCALE EXPERIMENTATION

Before coming to the final conclusions of this paper, the author would like to state the principle which he has been following in his boiler-water studies at Ohio State. It is this: To create a background of information by investigating, one at a time and under controlled conditions in an experimental boiler, the important factors that affect the carry over of liquid water into the steam. This studying of one factor at a time cannot be done to advantage in a commercially operating boiler, because the conditions are not so well under control and there is therefore no method of determining the effect of one condition by itself. There can be no scientific understanding of the effect of suspended solids, for example, without the knowledge that some kinds of solid matter reduce priming and other kinds increase it. Such knowledge can be obtained only by patiently trying one substance at a time.

The question, of course, arises as to whether the behavior of water in an experimental boiler is the same as in a large commercial one. Only a large number of direct experiments can answer this question, and it would perhaps pay to make a few of the more important ones. The experiment of Joseph and Hancock with a locomotive boiler cited previously is the only published case in point.

That there should be direct agreement between the results of small laboratory and commercial boilers is, however, not so important as it seems, because the main purpose of the small-scale experiments is to study the behavior of individual substances with the view of suggesting new ideas that may eventually help in solving some puzzling situation in actual practice. At any rate the author prefers to have his experimental work considered from this standpoint.

DEDUCTIONS FROM THE EVIDENCE

On studying the foregoing group of facts as brought out by experiments with glass flasks and small laboratory boilers, three points bearing on this question of the effect of solid matter stand out.

(*a*) Some kinds of solid matter increase priming, some kinds have no effect, and some kinds actually decrease priming. Examples have been found among solids added from the outside and among solids which are precipitated inside an operating boiler.

(*b*) Some kinds of solid matter that cause priming when first introduced into the boiler or when first precipitated inside the boiler lose that property on sufficient time of contact with the hot boiler water. The rate of loss in the case of solid matter which is added from the outside is more rapid the higher the temperature. The same is probably true of solids which are precipitated inside the boiler, but such an experiment has not yet been tried.

(*c*) Priming in general is greater at low than at high pressures.

Consideration of these three points shows that the question of solid matter should not be asked as formerly: Does solid matter in the boiler water increase priming? but rather in this way: What kinds of solid matter increase priming, and under what conditions? The following is perhaps worth stating as a working hypothesis. At low pressures, which mean also low temperatures, suspended solids may and frequently do increase priming, but at high pressures and temperatures the effect is less and is frequently absent.

This hypothesis is in harmony with flask experiments which were made at 100 C. At higher temperatures (pressures) the solids may lose their foam-stabilizing properties so rapidly that it will not be evident that they ever had such properties. In the early days of steam engineering when a pressure of 50 lb per sq in. was used and, incidentally, when feedwaters were not as good as now, it is at least a fair guess that suspended solids in the boilers nearly always promoted priming, and perhaps the opinions formed in that early day persist to the present.

Obviously, much more work must be done before a proper understanding of conditions will be attained. The final answer then will be either a method for the elimination of the undesirable conditions or a method for counteracting the effect of those conditions.

GENERAL ASPECTS

Let us now examine the general aspects of the question to see if there is any explanation for the fact that solids at low pressures and temperatures cause priming and at higher pressures and temperatures lose this property. The answer is, that this is in harmony with existing theory. Foam is not stabilized by solid matter unless the solid matter floats and the floatability is inversely proportional to the wettability of the solid. Ground flint, for example, is instantly wet by water solutions and sinks. It cannot have any effect on the foam because the foam is on the surface. On long boiling, the wettability of a solid that initially floats is increased, it sinks and therefore can no longer stabilize the foam bubbles. This increase in wettability proceeds faster the higher the temperature, and therefore in a modern steam boiler in which the temperature of the water is 200 C or higher, most solids become instantly wettable. The form of calcium carbonate which, as stated above, retains its priming tendencies for hours is apparently an exception to this rule. There is no explanation for this at present. The fact that the gelatinous precipitate of magnesium hydroxide does not increase priming is assumed to be due to its wettability.

It must, however, be confessed that no studies have as yet been made of the relative wettability or floatability of precipitates in a steam boiler.

The reason why some precipitates actually decrease priming is not so easy to explain. It is, however, in line with what every chemist knows about the prevention of bumping in liquids boiling in glass vessels. Bumping is violent ebullition and can be lessened or prevented by introducing certain kinds of solid matter into the liquid. The action is usually explained by assuming that the solid matter carries entrained air on its surface which thus furnishes a gaseous nucleus, so to speak, at which boiling goes on and prevents superheating. It is doubtful, however, if this explanation applies to precipitates formed inside a boiler. At any rate, whatever may be the fundamental reason, the observed fact that in the Ohio State experimental boiler, priming was reduced by certain forms of solid matter is not out of harmony with experience in the boiling of liquids in glass vessels at atmospheric pressure. In the Ohio State experiments the loss of priming effect on the part of one of the forms of calcium carbonate was accompanied by a change in physical characteristics. It became more crystalline and granular.

The fact that in experimental boilers (three widely different designs have been used at Ohio State) certain forms of solid matter actually reduce priming seems to be new. The author asks his more practical engineering friends if they have encountered such experiences in their work with commercial boilers.

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THE WORLD DEPRESSION

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THOUGH one may be interested in statistics of industrial activity which mark off several cycles in the United States from 1913 to 1929, ending with a "slump" in 1927 and a "boom" starting in 1928 which led to the recent collapse, one must trace causes of our past prolonged depression farther back than the year 1928. Lionel Robbins, in his essay on the past depression,[1] does not commit himself to a short-time cyclical analysis. To present a well-rounded picture of his essay on the past depression, one must trace, as he does, the background of the World War. Following a discussion of this background, Mr. Robbins' analysis of the genesis of the depression and the causes of its prolonged duration will be given. It is thought best to follow slavishly his work rather than to attempt a critical appraisal.

The World War brought into being mechanical equipment which was rendered superfluous when peace returned; it disrupted trade relationships and world prices; and it left a heritage of war debts and reparations which aggravated existing disorders. The industrial and geographical alteration of the factors of production necessitated by the war was only carried through by means of a centralization of control (cartels and governmental fixing of wages and prices) some of which remained and rendered our economic order less flexible to necessary readjustment.

During the 1920's much of the intense disorder of the post-war period came to an end. Budgets were balanced and currencies restored to some sort of stability. Great Britain returned to gold in 1925, and later France; international investment was resumed, trade revived, and a boom developed. But this profitability was primarily an industrial boom. World agriculture was none too well off. In England even manufacturing could be described as only moderately good. Austria was consuming her capital in a most unhealthy fashion. Germany was depending upon American capital. Great Britain had stabilized her currency at too high a level which depressed her export industries and she was a nation geared to capital export. France had stabilized at too low a level and with the United States was attracting gold.

While none of these factors can be said to be the cause of the depression, this background certainly justifies Mr. Robbins' statement: "Clearly, if the forces making for prosperity were to slacken, the ensuing depression was likely to be a depression of more than usual severity." And they did slacken. The American capital flow to Germany began to dry up, leaving that country in a precarious situation. Then came our stock-market crash. In 1929 an index of United States security prices stood around 200–210; in 1932 around 30-40; production in the chief manufacturing countries shrank 30 to 50 per cent; the value of world trade fell by two thirds; the International Labor Office in 1933 estimated something like thirty million unemployed.

What caused this depression? We cannot say that it happened because of the rapid fall in prices, though that fall brought "secondary deflation," for the fall in prices must itself be explained. Nor can we say that overproduction in relation to monetary demand at prevailing prices "caused" the depression, for that is simply putting the problem in a different way. Why did supply exceed demand in so many different markets? This question throws the problem into bold relief. Overproduction in one line of activity is not likely to cause a depression, for there is no reason to suppose that such a state of affairs would cause a general fall in demand. For example, if there is "overproduction" of wheat, implying low prices and a lack of profitability in that line, consumers and other producers benefit by such conditions and have more money to spend. And we cannot assume that the money thus saved will be "hoarded," for, again, that phenomenon largely results from depression psychology with its desire for increased liquidity. The low profitability in wheat production does imply low incomes for that group, which will continue until labor and capital have migrated to other lines of production, but such relative adjustments of supply to demand are no explanation of the simultaneous appearance of a lack of profitability in many lines of production.

Realizing the nature of the problem, many have attributed the depression to the lack of monetary demand—a general restriction of the supply of money, or, in other words, to "deflation." But in a broad sense there has been no curtailment in the supply of money. If deflation means a decreasing velocity of money and credit in circulation, such a condition has existed since the slump, but is no more an answer to our problem than is the phenomenon of falling prices.

Can this declining velocity of circulation be attributed to a shortage of gold? No. In the first place, gold was increasing rapidly enough. In the second place, a long-time trend of falling prices would not necessarily cause cyclical fluctuations. But what of the maldistribution of gold? If France and the United States were "sterilizing" their gold, and the countries losing gold were forced to contract credit, we would have something to work on. However, in the United States, from the spring of 1927 until late in 1928, there was an expansion of credit on a declining gold base. Also there is no evidence of sterilization in France. Furthermore, instead of the expected decrease in deposits in Great Britain, the opposite trend is noticeable. The maldistribution of gold, a result both of post-war stabilization of currencies at incorrect parities and of consequent monetary policy, was causing world-wide inflation and not deflation. Great Britain was resisting and offsetting her loss of gold, and this policy provided a basis for world inflation.

Let us return now and see if we can find a theoretically tenable explanation for the continued inflation and the resulting depression. The continued flow of gold to the United States would have been stopped by a normal rise in the interest rates in Great Britain, contraction of credit in that country with consequently lowered prices. But the Bank of England held rates down, through its discount policy and the flow of gold continued. Also, the deflation that did occur was resisted by labor and price fixing (both in government-protected spheres and by strong business combinations). Such resistance would

[1] "The Great Depression," by Lionel Robbins. The Macmillan Company, New York, 1934.

One of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

normally cause lowered production and unemployment. The volume of unemployment and conditions of trade in Great Britain following stabilization in 1925 seem to bear out the above position.

The receipt of gold by the United States should generate a pressure toward lowered interest rates. Let us work on this hypothesis. Lowered interest rates cause a *relative* rise in the prices of producers' goods (the heavy industries). It is to be noted that such a statement is consistent with a stationary or falling average of prices, as well as with a rising average of all prices. The reason for such a relative rise lies in the fact that the value of income-producing goods is the sum of the discounted value of their future services. The value of a machine producing a monetary income of $100 per year during the life of the machine is the sum of a series of money values for each of the years. The money value for any one year is that sum which, at the going interest rate, will yield $100 in that number of years. Thus all income-producing goods rise in value with a fall in the rate of interest, and the more durable goods rise more than the less durable. This relative rise in the prices of income-producing goods causes a diversion of the factors of production away from the production of consumption goods toward the production of these capital goods.

Such a diversion of the factors of production is perfectly normal if the fall in the rate of interest is the result of an increase in voluntary savings. However, if such a diversion results from bank expansion, trouble will arise as the investment becomes income and is, in turn, spent on consumers' goods, rather than being saved. As the investment funds become income, being paid out to the factors of production in the heavy industries, there will be a rise in wages (and other costs) and then an increase in the demand for consumers' goods. The old proportion between producers' and consumers' goods tends to reappear. As this happens there will be a general lack of profitability in the heavy industries. Mr. Robbins concludes that "once costs have begun to rise it would require a continuous increase in the rate of increase of credit to prevent the thing coming to disaster." The heavy industries are caught between rising costs and declining demand. Our cluster of "errors of anticipation" stands revealed.

The preceding analysis took its root in a maldistribution of gold. Mr. Robbins suggests another line of causation. An increasing productivity of capital would normally produce a corresponding rise in the rate of interest. If, however, as a result of faulty Federal Reserve policy, the rate is prevented from rising, an additional force operates to generate the inflationary cycle here described. Dislocations so generated are not simply monetary results. They represent an industrial distortion in the distribution of the factors of production.

Mr. Robbins paints realistically conditions prior to the boom in fitting his theory to the facts. Only one point will be mentioned here, namely, the policy of the Federal Reserve System. We succeeded in maintaining low interest rates in 1927, in an effort to keep from attracting gold and so to aid Great Britain. This action would have been unnecessary had British policy been different. In any case, it allowed the investment boom to gain such momentum that warnings and a later modification of discount policy were of no avail.

While the inflationary influence discussed in the foregoing can account for the genesis of the slump, they are hardly sufficient to account for the severity of the prolonged depression. Though it is impossible to discuss at length the factors contributing to the severity of the depression, we may at least set down the conditions which Mr. Robbins believes to be of most importance. Let us divide these influences into two groups: (1) The background of the abnormal post-war situation; and (2) the policies taken during the depression.

In the first category one must place the political unrest which most certainly added to business uncertainty. The factors of production were distributed in the light of a high political risk factor. Also there were the maladjustments left over from the war—the capital shortage in Germany, world-wide agricultural depression, new political boundaries, debts, and other similar factors. Then, finally, the capacity of the economic system to readjust itself had been weakened by cartels, state controls, and rigidities and distortions in the labor market. One must also add the qualitative effects of the boom—the prevalence of fraud, changes in the straightforward methods of finance (with a huge growth of fixed debt), and the ease of obtaining capital to form pools and other restrictive schemes.

The second set of influences, policies adopted in the face of the depression, though growing out of the desire to avoid the necessary deflation, in reality only made conditions worse. The restriction of international trade is one such factor. Countries, in a sense, attempted to become liquid, restricting their imports by quotas, exchange control, license arrangements, and new tariffs. This curtailment of international markets and international investment only forced world prices lower, and so distorted prices that one really has no business talking of "world" prices during the period.

Our policy in the United States has been an attempt to avoid adjustment. During the Hoover administration an attempt was made to maintain wages and dividends at the expense of reserves. This added to the relative increase in the demand for consumers' goods and decreased the demand for capital goods. And, finally, we attempted to prop up bad debts. But the persistence of bad business situations only prolongs uncertainty. Instead of pushing credit out at low rates in every direction, we should have maintained, as we did in former depressions, a high rate of discount and have discounted freely on good security. A quotation from Mr. Robbins will make clear his position:

> Nobody wishes for bankruptcies. Nobody likes liquidation as such. All that is contended is that when the extent of malinvestment and overindebtedness has passed a certain limit, measures which postpone liquidation only tend to make matters worse. No doubt in the first years of depression, to those who held short-run views of the disturbance, anything seemed preferable to a smash. But is it really clear, in the fourth year of the depression, that a more stringent policy in 1930 would have been likely to cause more disturbance and dislocation than the dislocation and disturbance which have actually been caused by its postponement?

Mr. Robbins' analysis of the world financial panic, starting in 1931, and of the chaos resulting from that panic, though an essential link in his reasoning, and the basis for his international monetary reconstruction policies, would require a too extended treatment to be included within this review. Likewise, Mr. Robbins' treatment of "restrictionism" must be omitted; however, we may note that he finds no cause for recovery in programs such as embodied in the Agricultural Adjustment Act.

In general, future policy should aim for a world-wide return to the gold standard, coupled with the removal of quotas and other of the more severe trade barriers, and an internal monetary policy designed not to secure price level stabilization, but to check investment booms. To the extent that we do not secure an even flow of investment, our depression policy should be one of general wage cuts in order to secure a minimum of unemployment and rapid rebuilding of destroyed capital.

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Variable-Pitch Airscrews

THE first part of this editorial is based on a paper read before The Royal Aeronautical Society, Feb. 3, 1936. The second part tells about the German Schwarz wood propeller. Only the second part is abstracted.

Briefly, the Schwarz system consists in coating the fabric-covered propeller blade with a film of cellulose acetate about 1 mm thick and subjecting the whole to considerable pressure at normal temperature in a special autoclave. The leading edge is further treated and protected by brass sheeting. The process results in such adhesion that it is not possible to tear off the fabric without bringing away wood with it, the covering being very hard and yet elastic. This process possesses the great advantage that it absolutely seals the surface of the wood and prevents the rapid exchange of moisture with the surrounding atmosphere which is one of the chief troubles with the wooden blade, on account of the liability to distortion involved. The covering is said to be as resistant as metal to erosion and abrasion and superior from the point of view of corrosion.

The Schwarz process presents a further advantage in connection with detachable blades and therefore seems to offer possibilities in the application of wooden variable-pitch screws, one of the chief difficulties with these being the matter of connection at the root to the boss. In the Schwarz process the root is especially impregnated and then compressed to about one third its size, machined, and screwed into a steel sleeve, after which impregnation at high pressure closes any possible interstices.

It is stated that the German Schwarz Company have produced several thousand fixed airscrews on this principle, and many hundreds of the detachable-blade type are in service on engines up to 900 hp. The majority of the German seaplanes and flying boats use them and in many cases, including the Luft Hansa South American service, they have replaced metal airscrews. An airscrew of the Schwarz detachable blade type is now under test at Farnborough, and so far, it is said, with satisfactory results. (*Engineering*, vol. 141, no. 3660, March 6, 1936, pp. 263–264)

FUELS AND FIRING

Coal Grindability by the Ball-Mill Method

THE purpose of this paper is to present data obtained from an investigation conducted on the grindability of coal by the American Society for Testing Materials by the tentative standard ball-mill method. This investigation has been conducted over a period of a year, during which time several hundred tests were run on a wide selection of different coals coming from Pennsylvania, Ohio, West Virginia, and Kentucky.

The data herewith presented tend to show that the tentative standard ball-mill method might give results that are misleading and that a volume measure might be more indicative of the true grindability of materials of varying specific gravity. A means whereby the time element might be reduced has been studied and other phases of this work such as preparation of samples, mechanical screening, reporting results, and duplicating tests have been investigated. The ball-mill method and the Hardgrove method as adopted for tentative standards by the A.S.T.M. do not give results that can be accurately correlated. It seems that the most practical way of obtaining grindability indexes is by eliminating surface factors and fine screening because the former are inaccurate and the latter difficult and expensive.

The following conclusions have been reached:

(1) The 500-gram weight of the 10- to 200-mesh material should be changed to approximately 750 cc volume.

(2) It might be permissible to shorten the method to 30 per cent minus 200 mesh and to calculate the results obtained on an 80 per cent basis whenever the characteristics of the coal in question are known, especially if the coal has a grindability index of 50 or more.

(3) The manner of preparing the sample to 1680 microns (minus 10 mesh, Tyler) should be optional in regard to type of crushing and screening equipment used, provided the method of preparation is followed.

(4) The selection of hand or mechanical screening should be optional.

(5) All grindability results should be reported on the 50,000 grindability-index scale.

(6) The error on duplicate tests made by the same laboratory should not exceed 3 per cent.

(7) One method only should be chosen as a standard because the results obtained by the two methods, now tentative standards, are not comparable. (Paper by C. G. Black before the February, 1936, meeting of A.I.M.E., 23 pp., 2 figs.)

Synthetic Gasolines in Belgium and France

THE Belgian National Foundation for Scientific Research has just published a report describing research on synthetic carbureting fuels. The disturbed condition of the coal business in the world has been one of the principal sources of unbalance from which Belgium is suffering. The production of a gasoline from coal would not only cut down the present huge imports of the former but help relieve the situation in the latter. Benzol and ethyl alcohol can be relied on as fuels only in peace times as in case of war they would all be utilized for the manufacture of explosives.

In its colonial possessions Belgium has a large source of fatty acids such as palm acid. If these are heated in the presence of a catalyst, such as zinc or magnesium chloride, 65 per cent of the fatty acid is converted into a material having characteristics close to those of gasoline and containing on an average 19 per cent of unsaturated hydrocarbons, 35 per cent of aromatic hydrocarbons, 8 per cent of naphthenes, and 38 per cent of aliphatic hydrocarbons. The aldehydes and remaining fatty acids can be eliminated by an alkaline treatment. While this improves the octane number, it has proved to be impossible to produce a material with an octane number higher than 31 and this is quite unsatisfactory as the market requires an octane number of at least 70. It would appear, there-

fore, that even at the price at which the fatty acids can be brought from the Congo region it would not be practical to manufacture gasoline from these acids.

Methyl alcohol comes next. Efforts have been made in Belgium to manufacture it as a means of utilizing the material coming from plants making synthetic ammonia. Since the beginning of the depression these plants have been working at only one third of their capacity. In this connection the report covers the standard process for making methyl alcohol and the processes developed by the Belgian Nitrogen Company and the Bethune Mines Company. In this way important sources for supplying methyl alcohol are available. It cannot be used alone, however, as a motor fuel because of its low heat content and the use of a mixture containing 75 per cent methyl alcohol, 15 per cent ethyl alcohol, and 15 per cent benzol (these figures are approximate only) has been recommended.

The conclusion at which the report arrives is that under the conditions existing in Belgium the only practical processes are those of Bergius and Fischer. (*Le Génie Civil*, vol. 108, no. 3, Jan. 18, 1936, pp. 59–62)

INTERNAL-COMBUSTION ENGINES

Gas-Engine Governor

THE article describes a gas compressor driven by a gas engine and built in England for a Japanese gas works.

One of the most interesting features of this engine is its main control which acts through a governor of the centrifugal type, fitted to the crankshaft end and acting directly on the throttle valve. The governor acts through leve s on to a vertical spindle, which gives the necessary positions required by load conditions to the air and gas valves. The main speed variation is obtained by means of handwheel adjustments on the horizontal compression spring at the end of the governor casing. As this spring is compressed by turning the handwheel, it acts against the main governor springs, through toggle levers. Fine adjustments to the throttle can be made by means of a small spring-loaded wheel on the throttle spindle. The engine may be set to run at any speed between 330 and 165 rpm. All moving parts, including the governor gear, are enclosed within the frame and base of the engine, and are pressure-lubricated by two valveless pumps, either of which has sufficient capacity to maintain the oil pressure. (*The Engineer*, vol. 161, no. 4182, March 6, 1936, p. 258, 3 figs.)

Period of the Vibratory Process Accompanying Combustion in Explosion-Type Motor

THE photographic recording of pressure-time diagrams taken by the photocathodic method developed by one of the authors of the original article, A. Labarthe uncovered on parts of the diagrams corresponding to the combustion process the existence of a vibratory phenomenon having a frequency of the order of 2000 periods per second.

The amplitude of these vibrations which are superimposed on the variations of pressure due to the combustion never exceeds under ordinary conditions 4 to 5 per cent of the maximum pressure. Very much greater amplitudes of vibration can be obtained, however, if the compression ratio is exceeded or highly detonating fuels are employed. The diagrams were taken in such a manner as to reduce the possibility of disturbances coming from the membrane of the apparatus, and a series of tests was made with different membranes in order to establish the fact that the vibrations here observed were not due to some such factors as thickness of membrane or the material from which it is made.

When the compression ratio was varied it was found that the new vibratory phenomena passed through a maximum for a compression ratio between 8.5 and 9 depending on the gasoline used. It then decreased and the operation of the motor became silent again. The phenomenon is easily observable on pressure-volume or pressure-time diagrams. Once in a while the generation of two waves is seen on the part of the diagram corresponding to the combustion. The increase in pressure becomes more rapid beginning with the ignition and the slower period of combustion is found to be considerably reduced. As soon as the motor, electrically started, resumes its operation without pinking, all vibration disappears from the diagram. Fig. 1, left, shows the successive stages of the passage from the detonating régime to the one free from pinking.

The ordinary Clapeyron diagram provides a better explanation of the loss of power observed in the detonating operation of the engine. The combustion of the major part of the fuel takes place considerably ahead of the top dead center.

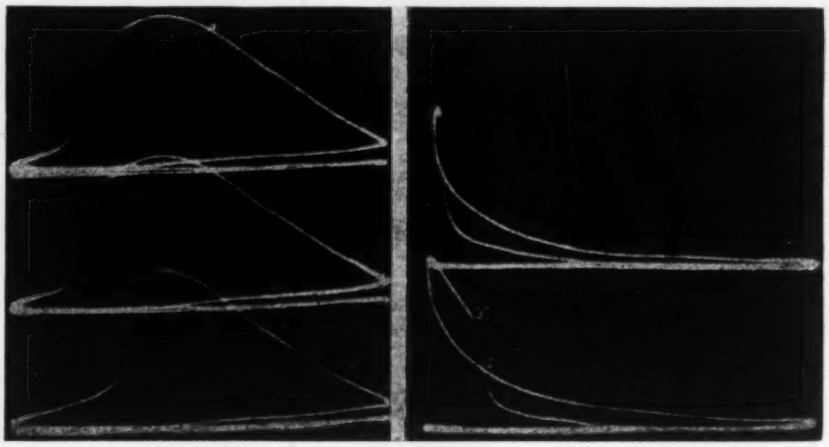


FIG. 1 INDICATOR DIAGRAMS OF A GASOLINE MOTOR, SHOWING, LEFT, PASSAGE FROM DETONATING TO NONDETONATING OPERATION, AND, RIGHT, PRESSURE VARIATION

The pressure following the mass ignition of the mixture increases up to point *K*, Fig. 1, right, at which a change in the slope of the curve takes place. As the pressure continues to increase up to dead center one may suppose that as the combustion is then completed the increase in pressure is due only to a compression during which a powerful exchange of heat with the walls takes place. Starting with the top dead center an expansion begins contrary to what happens normally. A part of the diagram corresponding to the expansion is found to be located above the part of the diagram corresponding to the combustion and cuts the combustion curve at the point *I*. Beyond that the expansion curve resumes its normal position with respect to the compression curve. When measured by the planimeter this portion of the diagram is reduced on the positive area and even in the case when the motor has not yet reached the stage of operation free from pinking, the generation of this negative

area may be observed and it is the presence of the second negative area on the Clapeyron diagram that provides an explanation of the loss of power in such an operation of the engine. (A. Labarth and R. Vichniewsky, *Comptes Rendus des Séances de l'Académie des Sciences*, vol. 202, no. 8, Feb. 24, 1936, pp. 631–634, 2 figs.)

Some Compression-Ignition-Engine Problems

THIS is an extensive article and because of lack of space can be abstracted only briefly.

The author inquires whether the principles underlying the standard practice of fuel injection for high-speed compression-ignition engines are not responsible for their restricted use. He also raises certain questions concerning the behavior of fuel injected in highly compressed and heated air, seeking a justification for keeping down at their present levels both the maximum pressure and the temperature at the end of the compression stroke.

According to his definition the standard for any fuel-injection system would be a fuel system, the performance of which would enable the design and manufacture of an ideal Diesel engine, the latter being an engine whose indicator diagram would exactly superimpose the diagram of an ideal Diesel cycle. The latter is a constant-pressure cycle and therefore is not in its working an approximation to the Carnot cycle. He gives an equation for the net work in Btu obtained from an ideal Diesel cycle with gases having constant specific heats. The function of an ideal fuel-injection system would be to maintain the pressure in the combustion chamber for a period as measured in crankshaft angular value such that at the end of the period the subsequent adiabatic expansion in the cylinder of the gases resulting from the fuel combustion would reduce their temperature to the absolute temperature at the end of the expansion stage T_2.

He next considers the rate of increase of volumetric capacity between the top dead center and end of injection period and finds that the working substance's variations in temperature and pressure due to its expansion in the cylinder and doing work on the piston head cannot be represented by a straight line. In other words it cannot be a constant rate. Therefore the ideal rate of fuel injection cannot be expressed by any linear equation, but must be shown by a curve following a path depending not only on the drop in pressure and temperature due to the expansion of the working substance in the cylinder and the work it does on the piston head, but also on the cooling factor introduced by the nonlinear equation representing the rate of increase of the relatively cold surface of the cylinder walls.

The jerk-pump system and its functioning are considered next, from the point of view of how the latter will meet the demands of the ideal cycle and of the ideal combustion conditions. The beginning of injection needs to be infinitesimal. Yet the needle valve brutally opens, delivering for a considerable period of the combustion stage a steady and constant stream of pulverized fuel equal in many cases to almost one half of the total charge, in addition to which these fuel-injection conditions are further complicated, particularly by the presence of the "delayed period." The reasons for these delayed periods are not really understood, but investigators have correlated to its effect two factors, temperature and pressure. In the author's opinion three or more factors must be taken into consideration, and he builds up a theory which tends to make out of the delayed period not a chemical reaction phenomenon but the resultant effect of at least five factors working in unison.

The conclusion at which the author arrives is that the jerk-pump system precludes the possibility of working to a legitimate maximum pressure and until a more scientific and accurate system of fuel injection is designed and the "delay period" factor better understood and controlled, compression-ignition engines will have to allow large margins of safety for the possible stresses due to excess of maximum allowable pressures as well as stresses beyond the safety margin in cylinder heads and crankcase. He next discusses spontaneous combustion in compression-ignition engine theory.

An apparent paradox is the fact that with a well-designed and manufactured jerk pump the delay period measured in crank angle remains nearly constant over a wide range of speeds, say, 750 to 2000 rpm. Yet, at the first sight, this seems an impossibility, since the delay period is a time factor and can only be expressed in crank-angle value if associated with a fuel and conditions of pressure, temperature, and speed of engine. Simple arithmetic demonstrates that if the delay period of a certain fuel be in an engine 1336 microseconds, and therefore 8 deg crank angle, when running at 1000 rpm, it must be 1336 microseconds, and therefore 16 deg when the same engine runs at 2000 rpm. Yet experience has proved this logic to be fallacious.

The author then lists a number of questions which if answered may help to find the solution of the delay-period problem. Neither these questions nor the answer to them can be reported because of lack of space. It may be stated however that in the author's opinion, spontaneous combustion in compression-ignition engines is the phenomenon resulting from an initial and partial dissociation of the fuel, caused by a local rise in temperature of pulverized fuel when injected in hot and compressed air. This local rise in temperature is the sum of two temperatures, viz., the temperature prevailing in the cylinder at the moment of injection, and an independent temperature due to the process of bringing to absolute rest the fast-moving pulverized fuel, i.e., the conversion of the kinetic energy stored in the fuel spray in motion into heat in its true state.

Five factors have to be considered: Temperature (air temperature); density (air pressure); kinetic energy (velocity of the droplet); adhesion (coefficient of friction of each fuel, coefficient of contact of each fuel); and diffusion (coefficients of thermal conductivity of each fuel from section to section of the fuel and from skin to mass). He then explains the paradox and adds that the answer to this question seems to prove the whole theory. (George Amery, in *The Engineer*, vol. 161, nos. 4184 and 4185, March 20 and 27, 1936, pp. 307–309 and 328–329)

MACHINE PARTS

Rope Pulleys

THE Lemay Company, of Germany, has developed a welded rope pulley claimed to be much lighter than a riveted or cast one. In this pulley the rims are bent on special machines, welded together, and then provided with arms and bosses.

The following figures are given to show the saving in weight. A pulley of structural steel of 25 in. diameter for a $^{9}/_{16}$–$^{13}/_{16}$ in. rope, weighs 62 lb, and a corresponding pulley of cast iron about 88 lb. A pulley of structural steel of the same size, but which has to be made wider, owing to a rope connection running over it, weighs 110 lb, and a corresponding pulley of cast steel, 220 lb. In the case of large pulleys the differences in weight are much greater, i.e., the weight of a wide cast pulley 55 in. in diameter is more than $2^{1}/_{2}$ times that of a corresponding pulley of structural steel.

Savings in weight of such magnitude, naturally, react favorably on the framework, especially when the pulleys are mounted at the tip of a log jib. There is also the possibility, on the other hand, when using pulleys of structural steel, of making the diameter of the pulleys larger than usual, which has the effect of reducing wear on the rope, a possibility of which extensive use is made in excavators. (*Lemay News*, vol. 10 B, no. 1, February, 1936, pp. B6–B7, 6 figs.)

MARINE ENGINEERING

Rowan-Götaverken System of Marine Propulsion

THE idea of using exhaust steam for marine propulsion is not new but it is only quite recently that it made any real headway. The following four systems are about the only ones actually used. Three of them, the Bauer-Wach, the Brown-Boveri, and the Parsons, have been extensively described. Less known is the Christensen engine where the exhaust turbine is coupled to the propeller shaft by a chain drive. It is built by the Danish Elsinore Shipyard. The Rowan-Götaverken system is a comparative newcomer. In the original Rowan design using the Lindholmen regenerative system the energy from the exhaust turbine was first transformed into electrical energy. Part of this electrical energy was used to drive the auxiliaries, and the surplus employed for superheating the steam supply. The thermodynamic and energy balances are fully discussed in the original article. This is not reported here as this system has been replaced by the Götaverken system invented by the Swedish engineer Johansson, in which the energy developed by the turbine is returned to the working steam at some intermediate stage in its expansion, usually at its exhaust from the high-pressure cylinder. The difference between this and the Lindholmen systems lies in the fact that whereas in the latter the energy is transformed into temperature energy in an irreversible manner, in the Götaverken system the transformation into pressure and temperature energy takes place in what could be regarded in the ideal case as a perfectly reversible operation, namely, an adiabatic compression. From consideration of the thermodynamics of the system the heat consumption per indicated horsepower-hour is 11,450 Btu.

The arrangement of the turbocompressor engine and condenser in the Rowan-Götaverken design is diagrammatically shown in two figures (15 and 16) in the original article. The triple-expansion engine is of standard type with the exception of the intermediate-pressure steam chest which embodies certain special features. The turbocompressor is entirely independent of the engine and can only be maintained in action by the pressure of the oil in the control cylinder. The absence of gears and mechanical connections is one of the outstanding features of this system. It renders maneuvering and reversing simple, as the turbocompressor adjusts itself to requirements. The turbocompressor itself is a self-contained unit with the exhaust turbine mounted on the same shaft as the steam compressor and the rotors running at from 4000 to 8000 rpm according to the size of the unit.

The original article reports details of the test carried out during a trial trip from Newcastle into the North Sea and later tests on other vessels made in the Firth of Clyde. These latter tests showed savings in heat consumption per indicated horsepower-hour of 18.6 per cent for one vessel and 18.3 for the other. These tests would indicate among other things that the low-pressure heater contributes an appreciable share to the heat in the feed.

In the trial without the compressor it is estimated that the steam consumed by the auxiliaries amounts to 9 per cent of the total feed; that consumed by the engines, therefore, amounts to 91 per cent of the total or 17,900 lb per hr. From the data pertaining to the high-pressure cylinder it is calculated that its efficiency ratio is 0.76, and that the steam at exhaust is superheated by about 43 F.

In the trial with the compressor, it is estimated that the steam consumed by the air ejector amounted to 0.5 per cent of the feed, that consumed by the auxiliaries 8.15 per cent, and that consumed by the main engines 91.35 per cent, 15,280 lb per hr. From the calculated heat drop in the high-pressure cylinder it is found that the steam leaves with 20 F superheat, i.e., at a temperature of 303 F. This result agrees remarkably well with the observed value. Unfortunately, agreement is not so close for the temperature of the steam at discharge from the compressor. It seems that the temperature registered by the thermometer, 359 F, is too low for the pressure of the steam, 78 lb per sq in. absolute, since this means that the compressor has added 1211 — 1185 = 26 Btu to each pound of steam, whereas about 80 Btu is available at the turbine shaft. Such a discrepancy suggests that the reading shown by the thermometer cannot have been correct, since the saving obtained with the turbocompressor would obviously never have been as high as 18.6 per cent.

Two further possibilities of this system have received attention. These were, first, the effect on the saving which may be derived from extracting steam for feed heating at the high-pressure exhaust before compression, and at the inlet to the intermediate-pressure cylinder, after compression. Second, the application of the compression process to the boiler steam. All these investigations were based on the figures previously obtained in the theoretical development, in order to arrive at comparative results. It might also be possible to apply the compressor to the two last stages of a triple-expansion engine and thus give the low-pressure cylinder some further advantage at the expense of the intermediate-pressure cylinder. But in view of the fact that the low-pressure cylinder is the worst converter of heat into mechanical energy, it is doubtful whether any higher economy would result. It seems to the author that further economy lies in the addition of a last-stage extraction feed heater. (Paper by J. B. O. Sneeden read before the Institution of Mechanical Engineers, Jan. 24, 1936, abstracted through *Engineering*, vol. 141, nos. 3655 and 3657, Jan. 31 and Feb. 14, 1936, pp. 115–117 and 189 to 192, and 2 plates, 32 figs.)

POWER-PLANT ENGINEERING

Emergency Turbines—Tate Valve Gear

A 300-KW back-pressure emergency turbine set has been installed recently by the Cornwall Electric Power Company (Great Britain). In a set of this kind the utmost reliability of the control gear is of primary importance and at the same time the operating gear must be of the simplest possible nature. In the present case, for hand control at the turbine, the operation of one valve sets the auxiliary steam-driven oil pumps in motion and with the attainment of an adequate working oil pressure the steam control valve automatically admits steam to the turbine. On reaching its designed speed the main governor takes control and the machine is then ready to take load up to its maximum rated output. The entire set, incidentally, is of such robust construction that it can be run up to speed in less than a minute, and give a supply of power and lighting for immediate use in the boiler house and turbine room. Remote operation is effected by means of a single push button and the operation is fully automatic in

case of the failure of the main electrical supply.

The details of the governor gear and connections for the automatic control of the turbine are given in the original article. A Tate controller is employed. This apparatus consists of a special motor coupled to the valve spindle by means of double spur-reduction gearing, the drive incorporating a solenoid-controlled spring clutch and a solenoid-operated valve-spindle clutch. The spring clutch is of the friction type and is proportioned to transmit the maximum permissible torque required to operate the valve.

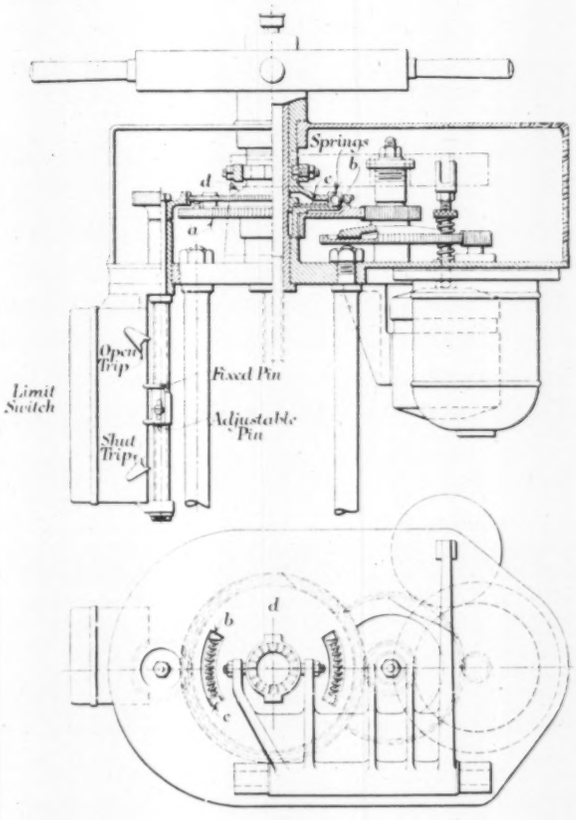


FIG. 2, ABOVE, AND FIG. 3, BELOW: TATE STEAM-TURBINE VALVE CONTROL GEAR

The valve-spindle clutch and spring clutch are interlocked and coupled to the solenoid, so that when the valve-spindle clutch is in position for hand operation, the spring clutch is disengaged, allowing the motor to revolve freely. As will be seen from Figs. 2 and 3, the solenoid is coupled to a lever on a horizontal shaft, a second, forked, lever at the other end of the shaft engaging with a member on the valve-spindle clutch. There is a second fork on the shaft, engaging with the friction clutch. When the solenoid is not energized, the cross shaft is rotated to release the friction clutch and to move the member *d* of the spindle clutch upward. Dogs are formed on the upper face of the member to engage with corresponding dogs on the bottom face of the handwheel. It will be observed from Fig. 3 that two slots are provided in the clutch member *d*, through the ends of which projections pass, with cushion springs between them. Two of these projections are formed on a tongue plate *b*, as shown in Fig. 2, and the other two on a spring plate *c*, also shown in Fig. 2. The tongue plate *b* is keyed to the spindle nut. When the handwheel is rotated in the direction to open the valve, the spindle nut is driven through the end of the slots in the clutch member coming into contact with the projections on the tongue plate. If the handwheel is rotated in the opposite direction, the tongue plate is again driven, but in this case through the cushion springs. It will be observed from Fig. 2 that dogs are also provided on the lower face of the clutch member *d*, with corresponding dogs on the upper face of the gear member *a*. When the handwheel is engaged, these dogs are separated so that the motor can run freely. When the solenoid is energized for power operation of the valve, the spring clutch is loaded and the upper dogs on the spindle clutch member are released and the lower dogs engaged. The tongue plate is turned in the two directions as in the case of hand operation, and when closing the valve, the first contact of the valve face and seat results in the cushion springs' being compressed, and the limit switch which shuts off the motor is so timed as not to come into operation until the valve is shut dead tight by the motor exerting its force through the compressed springs. The amount of compression varies from 5 to 10 deg, according to the pitch of the valve-spindle thread. The arrangement for operating the limit switch will be clear from Fig. 2, but it should be explained that this switch is arranged not only to cut out the motor, but also to release the solenoid and disengage the clutch, so that the motor is instantly released to prevent sudden arrest of the revolving parts. The completion of the stroke of the solenoid engages the handwheel with the valve spindle, and, as explained, disengages the spring clutch in readiness for the next operation. The flexibility of the spindle clutch is limited by a stop on the spring plate engaging with a slot in the tongue plate to protect the springs from excessive loading in the event of the valve's being seized up, or in any condition in which the valve spindle is prevented from moving. A condition of excessive overload, such as is caused by starting a jammed or seized-up valve, is met by the automatic releasing qualities of the two clutches in such a manner that no part of the valve or gear is subjected to excessive stress. The teeth on the lower face of the clutch member *d*, and on the upper face of the gear member *a*, already referred to, are formed with inclined faces, so that they separate in case of such an overload as that referred to. When such separation occurs, the clutch remains uncoupled for a period to permit the motor to accelerate, after which a rapid reengagement takes place which administers torsional impulses to the valve spindle. The clutch will continue to disengage and reengage in this manner until the excessive resistance is overcome without damage. Should the resistance be extreme and the valve refuse to move, even after repeated impulses, the prolonged continuation of the notching effect provides an audible warning and indicates that the valve is incapable of being traversed by the motor. This system of solenoid-operated clutches is such that there is instantaneous response to the action of the controller and limit switches, and there is no danger of overrunning or jamming. The mechanism automatically limits the torque and stresses to a safe maximum value, to which the various parts are subjected even when indiscriminately operated. (*Engineering*, vol. 141, no. 3656, Feb. 7, 1936, pp. 137–139 and a plate of drawings)

Operating Löffler Boilers in a Back-Pressure Power Plant

IN this plant constant superheat is maintained at all loads within the range of operation concerned, and at the same time any desired quantity of saturated steam can be taken from the boiler over the full range of load. The permissible density of boiler water is relatively high and deposition of salts in the turbine was reduced to a minimum by modification of the feedwater treatment.

The considerations determining the choice of Löffler boilers for this back-

pressure plant may be summarized as follows: The power required to drive the circulating pump constitutes a load on the boiler which is mainly (but not entirely) balanced by the delivery to the circulating steam of the heat equivalent of the internal work done by the pump. The remainder of the energy input to the pump is not recovered but, under suitable conditions, its amount is not serious. The first requirement is that the working pressure should be high, and this condition is fulfilled at Höchst where it is 1706 lb. The second consideration is that the inherent advantages of the Löffler system, particularly as regards constancy of superheat on variable load and relative indifference to high concentrations of salts, more than compensate for the cost of forced circulation. Finally, there is the elimination of intermediate superheating and the high degree of safety of the Löffler system.

Experience in the operation of the Höchst plant indicates that it can be worked with a boiler-water density of 0.5 Baumé without any difficulty. This corresponds to a concentration ratio of about 23 and 4.5 per cent blowdown. Higher concentration has not yet been tried for any considerable period, but it appears to be practicable. The feedwater used is taken from the river main and, according to season and rainfall, it has initially a hardness of from 8 to 14 deg. In addition the water carries a high proportion of organic impurities. Treatment commences with a thermal stage of 212 F, which reduces the temporary hardness to approximate equality with the permanent harndess. Addition of caustic-soda solution then converts the hardness to soluble salts, and the water, now at 2 deg hardness, is treated with bisodium phosphate and heated to 284 F, thus reducing it to 0.04 to 0.06 deg hardness. On starting the plant with this water treatment, salt deposits soon formed in the turbine. Addition of a small amount of sodium aluminate to the caustic-soda solution was found to assist precipitation of organic impurities. A more important change, however, was the neutralization of the prepared feedwater with acid, thus reducing the final caustic-soda content. No deposits of salts have since formed in the turbine.

The manner in which salts are transferred from the feedwater in the evaporating drum to the turbine is at present uncertain. From the fact that feedwater entering at 392 F is heated by steam at 932 F, it does not seem impossible that salts are heated above their melting point and actually evaporated. This theory is supported by the fact that salts in the turbine consist mainly of caustic soda, which melts at 608 F. However this may be, the modified feed treatment at Höchst has permitted operation with boiler water of 0.6 Baumé density, corresponding to a concentration ratio of 31 with feedwater of 12.6 grains per gal.

The operating risks of Löffler boilers are exceptionally low. A few tube bursts have occurred at Höchst, but only in the early days and with no serious consequences. It is not even necessary to shut down the boiler directly a burst occurs; arrangements for transferring the load can be made without haste. A high-speed gear on the stoker enables the fire to be run out quickly in case of emergency. In the event of sudden interruption of steam delivery, care must be taken that the steam temperature does not become excessive. The circulating pump must be kept running. If necessary, steam can be blown off above the roof. (G. Liebegott, address to German society of boiler supervision associations, Oct. 1, 1935, abstracted through *The Steam Engineer*, vol. 5, April, 1936, no. 55, pp. 289–291, 2 figs.)

POWER TRANSMISSION

Starting Acceleration of Diesel-Driven Cars

IN general the hydraulic drive consists of a fluid gear with a torque converter described for the sake of brevity as a converter. On the driving end everything remains constant while the driven end automatically adapts itself to all changes of load so that in the ideal case the product of torque times revolutions remains constant. Since, however, the angles in the blading of the converter have been selected for some given velocity of the flow of liquid, the variation of torque or revolution and hence the velocity of the flow of the liquid are accompanied by losses which reduce the efficiency of the drive. It becomes necessary, therefore, that the efficiency of a converter be at its optimum for a given number of revolutions. The curve of efficiency is therefore like a parabola which passes through the point of origin when the velocity $V = 0$ and attains its optimum value for a certain average value of velocity. The curve of efficiency must pass through the origin because, when the driven shaft is braked solid, a moment but no output should be transmitted. The curve of an ideal driven torque (for $\eta = 1$) is a hyperbola, since the torque times revolutions must always be constant. Because the efficiency of the converter is less than 100 per cent, the transmitted torque M_2 is smaller than the ideal torque M_{2i}. As a matter of fact actually the curve of torque M_2 is nearly a straight line. If it be assumed that the efficiency of the converter is an exact parabola it will be found that the curve of the actual driven torque M_2 is a perfect straight line.

The author next discusses briefly a case where the torque converter is not present, in which event the apparatus becomes a hydraulic coupling. In this case the driven moment is equal to the driving moment. Depending on the magnitude of the torque being transmitted, however, the number of revolutions of the driven end is not the same as that of the driving end, a certain slip occurring between the two halves and making the coupling perfectly elastic. This slip causes a loss of output proportional to the torque transmitted. The efficiency of such a coupling is therefore increasing when the moment transmitted is decreasing. By a proper selection of the diameter of the coupling (which should be as large as possible) the efficiency may be brought very close to 100 per cent when the torque is small.

The optimum value of the efficiency of a set including a torque converter lies at about one half of the maximum revolutions of the driven shaft and falls on both sides of that value. In a hydraulic coupling the optimum of value corresponds to small torques which means high revolutions of the driven shaft. Furthermore, because of the small difference in the revolutions of the driving and driven shaft, the hydraulic coupling can be properly applied only when the range of revolutions is small, because, if its velocity falls off, the velocity and hence the output of the motor fall off likewise. The two hydraulic elements by themselves do not seem to be suitable for use in motor vehicles, since the efficiency of a torque converter set at the maximum velocity is nearly zero, while in the case of a hydraulic coupling the low velocities do not produce enough output because of their deleterious effect on the motor.

It is to eliminate these two disadvantages that the two elements are used jointly. In starting and up to about two thirds of the maximum revolutions a torque converter is used. While it is a fact that at low revolutions its efficiency is poor it does deliver the large torque needed for starting (Fig. 4). It is at about $V = 0.5\ V_{max}$ that the converter reaches its best efficiency which de-

creases only slightly as the revolutions increase. At two thirds of the maximum velocity the hydraulic coupling takes the place of the converter. From now on the revolutions at the driving end differ from those at the driven end only by the amount of slippage, and therefore the revolutions and hence

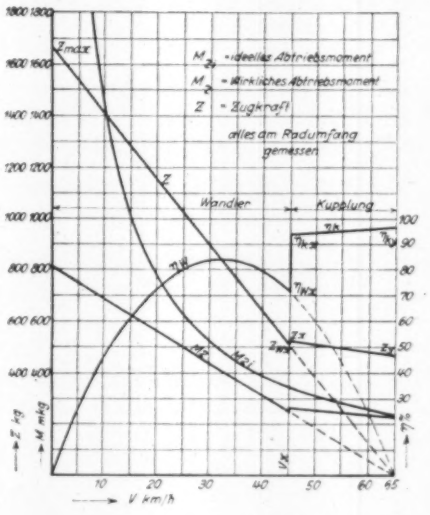


FIG. 4 RELATION BETWEEN TORQUE AND SPEED OF VEHICLE

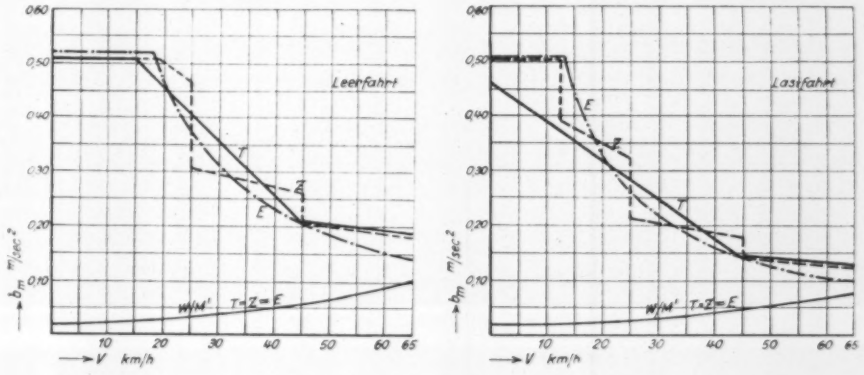
(*Wandler* = converter; *Kupplung* = coupling.)

the output of the motor are somewhat reduced. With increasing velocity, however, the output of the motor increases until at the maximum speed it attains the same maximum value which it had in the converter drive. However, since the curve of torque of an internal-combustion engine falls off somewhat with the increase of speed the curve of driven torque has the shape shown in Fig. 4 in the region marked *Kupplung* which means coupling. In the hydraulic-coupling drive the driving and the driven torques are equal and hence $M_1 = M_2$.

This collaboration of converter and coupling may be effected in two ways. The first is to locate the converter and hydraulic coupling in series and regulate the admission of oil in such a manner that the converter is filled first and only then the oil is admitted to the coupling. A second possible arrangement is as follows: An aggregate is provided such that a guide apparatus is rigidly connected with the housing by means of an automatically acting valve so that it is stationary with respect to both the turbine and the pump and can actually work as a guide apparatus. This arrangement gives a converter effect. When a certain predetermined speed is reached a valve opens automatically and thereupon a second valve, also automatic, connects the guide apparatus to the turbine which gives a hydraulic coupling. The differential torque $M_2 - M_1$ operating on the guide apparatus is used to actuate the valve.

From here the author proceeds to a mathematical analysis with the purpose of determining what starting acceleration can be obtained by means of such a fluid gear, assuming a given output of the motor and a given curve of efficiency.

A method of computation of the starting acceleration of a vehicle equipped with such a fluid converter for a given motor output is presented for the case in



FIGS. 5 AND 6 THEORETICAL ACCELERATION OF DIESEL-DRIVEN VEHICLES OF THREE TYPES—CHANGE-GEAR BOX, FLUID TORQUE CONVERTER, AND ELECTRICAL TRANSMISSION

(Left: For running at no load, *Leerfahrt*. Right: Under load, *Lastfahrt*.)

which the efficiency curve of such a converter is a parabola. With the efficiency curve here assumed it is found that, notwithstanding the low efficiency of the converter at starting, the acceleration at no load is substantially the same as that of a vehicle equipped with a gearbox, while the acceleration under load is only a few per cent lower. It is necessary to remember that in the discussion of change-gearbox operation it has been assumed that the shifting of gears occurs without any loss of time.

That the acceleration of a vehicle with a hydraulic drive under the conditions as to load assumed in the original article is somewhat slower than that of a change-speed gearbox drive, is explained by the fact that the friction draw is greater in this case and is not fully utilized by the converter.

Figs. 5 and 6 give the theoretical accelerations for driving under load and no load and for three types of vehicle drive when no road resistance is present. The influence of road resistance is indicated by a curve W/M' in Figs. 5 and 6. From these figures it appears that the curve of acceleration for a vehicle with a fluid converter runs much more uniformly than the stepwise curve for a vehicle with change-gear drive. The curve of a Diesel-electric vehicle also runs fairly uniformly, but in this case we are dealing with a double transformation of energy, and moreover, electric transmission results in a greater weight of vehicle. This is noticeable at no-load running (Fig. 6). Here the weight of the electric transmission is a much greater percentage of the total, and as a result the acceleration of a Diesel-electric vehicle is less at no-load running than it is in the two vehicles with mechanical transmission.

Taking into consideration the fact that the shifting of the gears in a change gear drive is always accompanied by a certain loss of time, it will appear that in so far as starting acceleration is concerned, the liquid drive is at least equal to the change-gear drive under the conditions of the efficiency assumed. Further, since the total computation lies on the assumption that the curve of efficiency of the converter is a parabola, it is desirable to determine by thorough tests to what extent this assumption of variation of efficiency is justified. (Dr. of Engg., L. Kinkeldei in *Glasers Annalen*, vol. 116, no. 9, May 1, 1935, pp. 69-73, 3 figs.)

PUMPS

Centrifugal-Pump Efficiencies

THIS editorial claims that the determination of efficiency of centrifugal pumps is in such a state as to deserve immediate, possibly drastic, action of some kind. A case is mentioned in which a British firm with an internationa' reputation of the highest refused to bid for an order against continental competitors whom it knew were prepared

to guarantee efficiencies outside the bounds of possibility. The British Standards Institution is working to secure an international agreement in this field.

Unfortunately, the provision of a formula for tests is not enough, for even when the same or almost the same method of estimation of efficiency is employed, the several guarantees may differ by as much as or more than 10 per cent.

The British Standards Specification for Pump Tests (No. 599) is in close agreement with the Australian and American codes. Pump tests, however, are notoriously difficult to carry out and some makers are not above adopting rules for the increase of efficiencies which only an expert trained in and experienced with this class of tests can detect.

Two fruitful causes of error are erroneously high readings of head and of quantity delivered. Pump experts are well aware that there are ways of placing and connecting gages by which a pump gets a double credit for the velocity head in the pipe. This device is difficult to detect. The measurement of discharge by formula also requires caution. In a few cases, the pumping out of docks for example, accurate and precise determination is possible. When pumps are used for that purpose the claim for absurdly high efficiencies is never fully sustained by properly conducted tests.

But in the majority of cases there is no such convenient method of measuring the quantity pumped and reliance has to be placed on weirs or other measuring devices. Then the maker has a convenient diversity of formulas from which to select that which is most convenient to him. Thus for a given weir we have the following results: By the Francis formula, 308 gpm; by the Unwin, 324 gpm; by the Box, 358 gpm, and by the B.S.I. (4a), 317 gpm. All these formulas have the weight of authority behind them, and the maker is perfectly justified in selecting that which suits him best. It is for the purchaser or the consulting engineer to satisfy himself that competitive guarantees are based on the same method and formula, and that that method and formula are used for conducting the acceptance tests.

It is necessary, too, that in the tests the observations should be made in exactly the same way for all. For example, a discrepancy can arise if the zero reading of a weir head is taken as the water level when water has just ceased to flow over the weir; it should be noticed that surface tension may cause the readings to vary by as much, we are informed, as one tenth of an inch, which may be equivalent to a variation in the neighborhood of as much as 4 per cent in the discharge as calculated. (*The Engineer*, vol. 161, no. 4182, March 6, 1936, p. 261)

REFRIGERATION

Direct-Expansion Air Coolers

SOME of the troubles of coolers for cold stores are that they are inclined to run rather wet and, with float-control valves, they have the additional disadvantage of not working well in parallel nor lending themselves to high duty when forced. The author has attacked this problem by providing forced circulation on the air cooler itself and designing a battery more in keeping with modern high-duty steam-boiler practice.

The principle of the arrangement will be gathered from Fig. 7. The strands of piping are short, having a length of about 200 ft each, and are inclined to the horizontal. The pipes are, however, connected to a small liquid header at

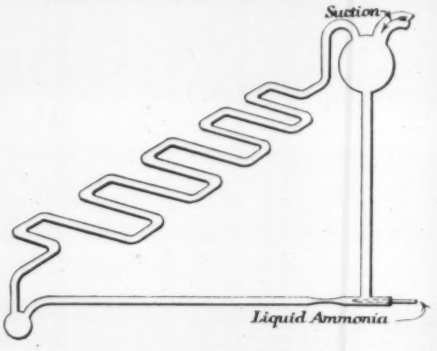


FIG. 7 DIRECT-EXPANSION AIR COOLER

the bottom and to a large gas header at the top, the entry being arranged in an inverted U to throw down the spray in the top header. The ammonia collects in this header and passes down a return tube outside the cooler into which is fitted an injector. All liquid ammonia entering the cooler passes through this nozzle, so that there is a forced circulation of ammonia between the two headers.

By using this means it is obviously possible to clear the top drum of any liquid ammonia and, moreover, to set up a condition of violent agitation in the strands of the cooler, which is conducive to improved heat transmission. (Edgar A. Griffiths, *Engineering*, vol. 141, no. 3663, March 27, 1936, p. 331, 2 figs.)

TESTING AND MEASUREMENTS

Precision Method for Measurement of Condenser-Tube-Surface Temperatures for the Determination of Film Coefficients in Heat Transmission

IT IS said to have been found that when drop condensation prevails thermocouples connected to the condenser-tube surface show that irregular and erratic temperature fluctuations of ±4 F occurred as the thickness of the insulating water drop changed, making it impossible to determine any accurate "average" temperature for this particular spot. There are other objections to the use of thermocouples for this work. The resistance-wire method in which a platinum-wire resistance thermometer is embedded in the wall of a condenser tube has also important objections which led to the adoption of a method in which the tube itself is used as a resistance thermometer. The paper deals with the interpretation of the resistance so measured and the means of calculating the surface temperature of the tube from it. Several methods of accurately determining this resistance are discussed with possible sources of error and their magnitude. (Joseph O. Jeffrey, Cornell University Engineering Experiment Station, Bulletin No. 21, March, 1936, 34 pp., 4 figs.)

THERMODYNAMICS

New Plank Equation for the Critical Range

THE behavior of matter in the critical range is as a rule expressed by the classical theory of continuity as formulated by T. Andrews and J. D. van der Waals. According to this theory the densities of saturated steam and liquid at the critical temperature are equal to each other so that one is dealing here with the homogeneous phase. On the other hand the two-phase theory of the critical state represented mainly by Cailletet and Colardeau, de Heen, Traube, Teichner, Callendar and, lately, Tapp, Steacie, and Maass, claims that at the critical point, that is, where the meniscus in the test tube disappears, pressure differences as high as 100 per cent have been observed. It would appear that the two theories can be reconciled as it has been observed that there exist small local differences of temperature in the test space and to these differences of temperature correspond small changes of pressure and while these changes are small they are apt to produce material differences of density in the immediate

proximity of the critical state. The critical range may therefore be considered as a metastable range. The van der Waals equation, according to which at the critical point the three roots of the volume coincide, does not correctly represent the magnitudes of the actual changes of density. The contact between the critical isotherm in the pressure-volume diagram and the line of constant critical pressure is not sufficiently close and the actual processes can be conceived in the form of an equation of state only by raising the power of the equation for v so that more than three roots would coincide at the critical point.

An important step in this direction was made by A. Wohl who proposed an equation of state of the fourth power. Equations of even powers, however, do not provide a turning point of the critical isotherm at the critical point and furthermore the Wohl equation holds good only for nonassociated normal materials. The thermic behavior at the critical point, however, may be well represented by an equation of the fifth power

$$P = \frac{RT}{v-b} - \frac{A_2}{(v-b)^2} + \frac{A_3}{(v-b)^3} - \frac{A_4}{(v-b)^4} + \frac{A_5}{(v-b)^5}$$

In this equation the number of constants is greater by one than the power of the equation: P is the pressure, T absolute temperature, v specific volume, R gas constant, b covolume, A_2, A_3, A_4, and A_5 coefficients. To make this equation apply to "normal materials" as does the Wohl equation it is necessary to insert the following values

$$b = \frac{1}{4} U_k$$

and

$$s = \frac{RI_k}{P_k U_k} = 3.75$$

Generally, the equation $s = 5(1 - b/U_k)$ holds good.

In the case of associated materials such as water, b can be adjusted to the value of s as determined by measurement. As an illustration it is stated that the equation reproduces correctly the course of values obtained by measurement of the critical isotherm of water vapor, providing $b = \frac{1}{8} V_k$. In the discussion of this paper it was pointed out how difficult it is to express by a single equation of state both the critical range and the range of lower pressures (paper presented by R. Plank at the meeting of the special board for heat investigation of the Verein Deutscher Ingenieure, Oct. 7 and 8, 1935, abstracted through *Zeitschrift des Vereines deutscher Ingenieure*, vol. 80, no. 11, March 14, 1936, p. 306)

Viscosity of Water and Steam

IT was announced in 1934 that by using an experimental arrangement comprising a capillary made of quartz or platinum the viscosity of liquid water has been determined for temperatures up to 371 C and the viscosity of water vapor up to the critical range. The results obtained are shown in Fig. 8 and indicate that the viscosity of liquid water depends

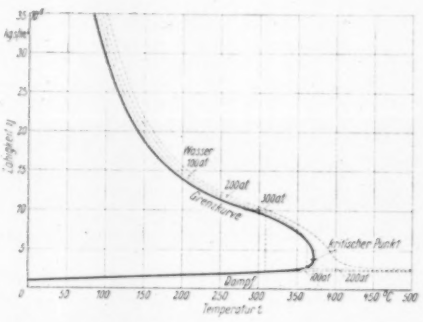


FIG. 8 BOUNDARY CURVES AND ISOBARS, VISCOSITY OF WATER AND STEAM

(Ordinates, viscosity; abscissas, temperatures; *Wasser* = water; *Grenzkurve* = boundary curve; *Dampf* = steam; *Kritischer Punkt* = critical point.)

exclusively on its density while the viscosity of water vapor depends on the density and, to a smaller extent, on the temperature.

It has been found that the experimental data thus obtained agree with the functional temperature relation given by the formula of Sutherland, according to H. Speyerer and W. Schugajew. The measured "pressure coefficient of viscosity" is, however, much smaller than the one found by Speyerer and W. Schiller so that the independence of viscosity from pressure given by Schugajew within his error limit of ±6 per cent (unfortunately, Schugajew does not give the actual experimental values) is confirmed up to a pressure of approximately 93 atm. On the other hand the values of Speyerer, for example at 300 C and 10 atm, lie about 10 per cent higher than those determined by measurement in Danzig; the values of Schiller, taken, for example, at 300 C and 30 atm are 50 per cent higher than the Danzig values, while the values for 310 C and 100 atm extrapolated by Ruppel from the data of Speyerer and Schiller are 130 per cent higher than the Danzig values.

In reply to an inquiry during the discussion of the paper as to the values of viscosity at higher temperatures, it was stated that the correspondence between the Sutherland equation and the results of measurements permits extrapolation to higher temperatures with a precision sufficient for practical purposes. (Paper presented by K. Sigwart, of Danzig, at the meeting of the special board for heat investigation of the Verein deutscher Ingenieure, Oct. 7 and 8, 1935, abstracted through *Zeitschrift des Vereines deutscher Ingenieure*, vol. 80, no. 11, March 14, 1936, p. 307, 1 fig.)

VARIA

Shortage of Skilled Labor in Great Britain

THIS is an editorial dealing with the White paper entitled "Statement Relative to Defense." Among other things it contains the testimony of Mr. Burton of the Birmingham Small Arms Company. With the unemployment due to the depression and breakdown of the former continuity of training and practice from boyhood through manhood to old age, it was inevitable that a state should come when the gaps would make themselves felt. Mr. Burton's evidence went to show that skilled labor was not only difficult to obtain but that much of it was also impossible to train on the high standard required in small arms. There were quite a number of the older men today who had never got beyond calipers and foot rules, who had no notion of the vernier, and whose sense of touch cannot any more be developed to take account of the niceties now essential. Such men beyond a certain age are not likely to adapt themselves to the refinements required in arms manufacture.

It is not implied that age and skill do not go together. Many of the works up and down the country can boast of employees whose length of service has run for fifty years or more and who are adept at particular jobs, but this is quite a different matter from drawing at random from the ranks of the unemployed and setting the men to work of a type and quality they had never seen before. In their program the Government puts upon the "industries concerned" the onus of finding the necessary craftsmen. It is not clear whether the industries here means the employers or the unions, or both, but it appears to us a case for something more than this. It is suggested that the Government assist in training suitable labor from among, say, the younger tradesmen. (*Engineering*, vol. 141, no. 3661, March 13, 1936, pp. 289–90)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

Leadership or Scholarship

To the Editor:

Dean Freund in his article, "Leadership—or Scientific Scholarship" in the April, 1936, issue of Mechanical Engineering brings out two points which cannot receive too much emphasis and which should receive wide circulation among engineering students.

The first point is psychological: "The researcher is ordinarily a lone wolf." Students who do not fit easily into this category should examine themselves carefully before deciding that they are exceptions to the rule and committing themselves to specialized research programs in graduate school—or even in undergraduate work. I added "undergraduate work" because in some colleges this decision must be reached by the end of the sophomore year.

The second point is economic: "The researcher must always be very much in the minority." For students who choose research work, this spells trouble if they are temperamentally and intellectually unsuited for such activity. It means also that the ladder is too narrow for second-rate researchers to climb—and they would be well-advised not to start.

These two points together mean that the majority of engineering students should "seek breadth rather than specialization" for their own happiness and economic safety. Perhaps the employment figures of Stevens Institute of Technology cited in an editorial in the same issue of Mechanical Engineering are not accident: I understand that the curriculum there "seeks breadth rather than specialization" and the years 1930-1936 were an acid test of economic usefulness. Perhaps, also, reasoning along this line is responsible for the graduate program in administrative engineering at Harvard's Graduate School of Engineering, which consists of one year at the Harvard Business School and one at the Engineering School with one or two Business School courses.

I suspect that Dean Freund may have overstated his own feelings when he said "the leader is greater than the expert." But in view of the comparatively rare combination of inherent qualities necessary for success in research work, I think that even hyperbole is justified if it will bring home to students the seriousness of the decision facing them.

Esty Foster.[1]

Who Invented the Cotton Gin?

To the Editor:

The following item appeared in the *New York Times* a few weeks ago:

New Orleans, April 3.—Mrs. Margaret Hess of Morocco, Ind., member of the Select Council of the National Inventors Congress, declared today that the cotton gin was invented by a woman, not by Eli Whitney.

In an address on "Women in Invention," Mrs. Hess asserted that Mrs. Nathanael Greene, wife of the Revolutionary hero, conceived the idea that led to the cotton gin.

"After she had developed a method for separating the cotton from its seed, Mrs. Greene entrusted the making of the machine to Eli Whitney, who was boarding with her, who had a Yankee's skill in the use of tools."

This is interesting, if true. Most great inventions, such as the steam engine, steamboat, locomotive, and automobile, are the work of a number of persons, often widely separated both as to time and place. The cotton gin is unique among the major inventions as having been developed by one person, and one alone. The first model, completed in ten days, worked perfectly and contained all the essential elements of the modern gin. The circumstances of its inception are better known than those of any other invention I know. Clear and detailed accounts of it are available from reliable sources.

Prof. Dennison Olmsted, and Prof. Benjamin Silliman, both of Yale College, and life-long friends of Whitney, published memoirs of Eli Whitney in the *American Journal of Science and Arts* in 1832, only seven years after Whitney's death. An account of the invention also appears in "Most Eminent American Mechanics," published by Henry Howe in 1842, and further details are given by William P. Blake, who was related to the Whitney family, in Volume 5 of the New Haven Historical Society papers. These throw light on the news item I have quoted. They all agree and supplement each other in a way to supply a clear picture of what happened.

When Whitney was graduated from Yale College in 1792, he decided to adopt the law as his profession, and accepted an offer of "80 Guineas a year" to go to South Carolina as a tutor in a gentleman's family and at the same time to study law. On the sailing vessel, on his way down to Savannah that fall, he met Mrs. Greene the widow of General Nathanael Greene, who was returning from a visit to her old home in the north, and Mr. Phineas Miller. Mrs. Greene, far from being a boarding-house keeper, was the mistress of a large plantation at Mulberry Grove, near Savannah, and "a brilliant and attractive woman of extended and influential social connections." Mr. Miller, like Whitney, was a graduate of Yale, and a lawyer. He had come to Georgia as a tutor in General Greene's family, and at the time was manager of the plantation where there were in all more than fifty people. Soon after he married Mrs. Greene.

Whitney, on his arrival at Savannah, found that his proposed employer had engaged another teacher, leaving Whitney stranded and entirely without resources. Mrs. Greene, who had taken a keen liking for him, said to him, "My young friend, you propose studying the law; make my house your home—your room your castle, and pursue what studies you please." He accepted this invitation and began to read law under the direction of Mr. Miller.

Mrs. Greene was engaged on a piece of embroidery in which she employed a peculiar frame called a tambour, which gave her much trouble. Whitney, who had all his life been skillful with tools, speedily produced a frame made on an entirely new plan, which greatly delighted her, and desiring to requite her hospitality he utilized his ingenuity in many other ways. The inception of the cotton-gin is described by Professor Olmsted as follows:

Not long afterwards, a large party of gentlemen came from Augusta and the Upper Coun-

[1] Assistant Dean, Graduate School of Business Administration, Harvard University, Boston, Mass.

try, to visit the family of Gen. Greene, consisting principally of officers who had served under the General in the Revolutionary army. Among the number were Major Bremen, Major Forsyth, and Major Pendleton. They fell into conversation upon the state of agriculture among them, and expressed great regret that there was no means of cleaning the green seed cotton, or separating it from its seed, since all the lands which were unsuitable for the cultivation of rice, would yield large crops of cotton. But until ingenuity could devise some machine which would greatly facilitate the process of cleaning, it was in vain to think of raising cotton for market. Separating one pound of the clean staple from the seed was a day's work for a woman; but the time usually devoted to picking cotton was the evening, after the labor of the field was over. Then the slaves, men, women, and children, were collected in circles with one whose duty it was to rouse the dozing and quicken the indolent. While the company were engaged in this conversation, "gentlemen (said Mrs. Greene), apply to my young friend Mr. Whitney—he can make anything." Upon which she conducted them into a neighboring room, and showed them her tambour frame, and a number of toys which Mr. W. had made, or repaired for the children. She then introduced the gentlemen to Whitney himself, extolling his genius, and commending him to their notice and friendship. He modestly disclaimed all pretensions to mechanical genius; and when they named their object, he replied that he had never seen either cotton or cotton seed in his life. Mrs. G. said to one of the gentlemen, "*I have accomplished my aim.* Mr. Whitney is a very deserving young man, *and to bring him into notice was my object.* The interest which our friends now feel for him, will, I hope, lead to his getting some employment to enable him to prosecute the study of the law."[2]

It will be seen that Mrs. Green played a very real and creditable part. Through this chance conversation, she brought the need and the man together, but this is far from constituting invention.

The morning after this incident, Whitney went to Savannah in search of some cotton. It was off season and cotton was not plentiful then as it is now, but he found a small parcel of it, brought it home, and went to work in the basement of the house. He made tools suited for his purpose, drew his own wire, and in ten days produced a working model which left no doubt of the success of his machine. Only Mrs. Greene and Mr. Miller knew of his work.

When it was done, Mrs. Greene invited friends from different parts of the state to witness its operation, which they did to their astonishment and delight. And yet from none of these, so far as I know, has there ever been any claim on behalf of Mrs. Greene for the invention. Most significant of all is the fact that none ever came from Mr. Miller. He married Mrs. Greene at about this time and was familiar with every circumstance surrounding the invention. He aided Whitney in his application for a patent, formed the partnership of Miller & Whitney with him on May 27, 1793, and worked with him as a partner until his death in 1803. Such a course would have been inexplicable if the invention had really been made by his own wife.

An application was made for patent in June, 1793. Thomas Jefferson, who, as Secretary of State, would issue the patent, was keenly interested in it and wrote to Whitney asking questions about it as he wished to "engage one of them" for his own use. Whitney replied on November 24, 1793, "It is about a year since I first turned my attention to constructing this machine, at which time I was in the State of Georgia. Within about ten days after *my first conception of the plan* I had a small, though imperfect model.[2] Experiments with this encouraged me to make one on a larger scale.... etc." Here Whitney distinctly claims the invention as *his*.

Owing to the immense economic value of this invention, it was the subject of bitter litigation. In the famous suit before Judge Johnson, which established the patent, it was attacked on three grounds, the first of which was that the invention was not original. In its decision the court said, "To support the originality of the invention the complainants (i.e., Miller & Whitney) have produced a variety of depositions of witnesses, examined under commission, whose examination expressly *proves the origin, progress, and completion of the machine by Whitney*, one of the copartners.[2] Persons who were made privy to his first discovery, testify to the several experiments which he made in their presence before he ventured to expose his invention to the scrutiny of the public eye. But it is not necessary to resort to such testimony to maintain this point. The jealousy of the artist to maintain that reputation which his ingenuity has justly acquired, has urged him to unnecessary pains on this subject."

From the foregoing we see that the reliable accounts, which give in detail the circumstances surrounding the invention of the cotton gin, all credit it to Whitney. Whitney claimed it, this claim was acquiesced in by Mr. Miller, and the findings of the United States Court as to the origin, progress, and completion of the invention substantiate that claim. Mrs. Greene was the means of bringing to Whitney his opportunity and she gave him encouragement and a place in which to work, but to attribute the invention to any other than Eli Whitney seems little short of fantastic.

JOSEPH W. ROE.[3]

[2] The italics are the writer's.

[3] Professor of Industrial Engineering, New York University, New York, N. Y. Mem. A.S.M.E.

Furnace Bottoms for Tapping Molten Ash

BY E. E. HUNTER[1]

IN A PAPER entitled, "Furnace Bottoms for Tapping Molten Ash," by R. Shellenberger, of the Babcock and Wilcox Company, New York, N. Y., presented under the auspices of the Fuels Division at the Annual Meeting, New York, N. Y., December 2 to 6, 1935, of The American Society of Mechanical Engineers, and published in the January, 1936, issue of MECHANICAL ENGINEERING, the author reviewed designs of typical installations and experiences with this type of furnace.

There are in service, he said, 80 slag-tap furnaces operating on coals with ash-fusion temperatures ranging from 1900 to 2550 F, with recent practice extending into even higher values of this temperature. As a result of experience to date with a relative large number of slag-tap installations, the author presented a list of eight advantages that he had seen realized through the use of the slag-tap furnace.

The discussion which this paper evoked follows:

The paper under discussion is a constructive summary of what has been learned in the development of furnaces with bottoms for tapping ash in the molten state and points the way to a better design. Mr. Shellenberger followed the general outline of development as the writer's experience indicates it should proceed. However, the paper minimizes the probable difficulties with this type of furnace.

It is implied that a continuous tapping system can be used at will. While this is possible, there are few installations where operating conditions are such that this procedure would be economically justified, owing to the attendant labor involved. While the water-cooled spout does prevent sticking of the molten slag, it greatly increases the tendency of the slag to freeze. This requires almost constant attendance. The

[1] Superintendent of Generation, Oklahoma Gas and Electric Company, Oklahoma City, Okla. Mem. A.S.M.E.

hydraulic gate for shutting off and opening the spout is mentioned. The writer has been unable to see any particular advantage in an elaborate arrangement for this purpose, particularly with the water-cooled spout. Any sort of simple safety gate which could be closed after the clay balls are inserted should suffice.

The statement that the slag-tap furnace is adapted inherently to high rating and high availability is true, but slightly misleading, in that it does not mention the important accompanying factor of boiler-tube slagging at high ratings. This cleaning alone is responsible for the major portion of boiler outage time with low-grade fuel.

The Oklahoma Gas and Electric Company, at the Horse Shoe Lake Station, near Oklahoma City, Okla., has two slag-tap pulverized-fuel boilers rated at 250,000 lb of steam per hr and operating at 300 lb per sq in. and 725 F final steam temperature. Each of these boilers is fired from one side by four intertube burners with a maximum heat liberation of 25,000 Btu per cu ft. Furnaces are equipped with waterwalls covered with cast-iron blocks. Unit pulverizers are used.

These boilers were installed in 1928 and were originally equipped with refractory bottoms with a slag spout in the center of each side wall. Pure iron and iron sulphide formed in the furnace, displacing the refractory. Growth of the bed as discussed by Mr. Shellenberger caused distortion of waterwall tubes and numerous slag leaks.

In 1932 the waterwall tubes were straightened and a water-cooled floor installed with a spring and buckstay arrangement for holding the walls in position. Floor tubes were covered with cast-iron blocks. Only one slag spout, located near the center of one side wall, was provided for each furnace. Floor blocks were covered with chrome refractory. Depth of the refractory varied from 1 in. at the rear of the furnace to 5 in. at the front of the furnace. The refractory material was installed so that there was a gradual slope toward the slag spout from all directions.

Since installing the water-cooled floors, our experience conforms with Mr. Shellenberger's as to the formation of iron sulphide and the necessity of maintaining a high degree of fineness. A fineness of 70 per cent through a 200-mesh screen and 98 per cent through a 50-mesh screen gives good furnace conditions with little fuel accumulating on the furnace floor while operating at high ratings. At low ratings this would not be sufficient fineness. At medium and low ratings, we maintain a fineness in excess of 90 per cent through the 200-mesh and more than 99.5 per cent through the 50-mesh at the expense of a little power. At all ratings, including the lowest possible, it is necessary to operate both mills and all four burners to reduce unburned-carbon accumulations in the furnace. At ratings below 100,000 lb of steam per hr, fuel accumulates in piles on the furnace floor where turbulence is low. This accumulation is agitated periodically with an air lance to prevent a reducing condition and the resulting formation of iron.

It is impossible to eliminate entirely the formation of iron and iron sulphide. Some iron sulphide is usually tapped out near the end of the tapping period. The remaining iron and iron sulphide has a tendency to accumulate gradually within a few feet of the slag spout, eroding and displacing the chrome refractory. Accumulation of iron sulphide causes little trouble in tapping as it has a fairly low coefficient of heat transmission. When iron in a pure form collects in the vicinity of the slag spout to such an extent that it filters through the chrome refractory and makes contact with the cast-iron floor blocks, it conducts heat so rapidly that it is difficult to keep the surface molten. When this is experienced possibly once or twice a year, the iron and slag within a few feet of the slag spout are broken out and the chrome refractory replaced.

We normally tap until the depth of slag in front of the slag spout is $2^1/_2$ in. Below this point slag runs so slowly that further tapping is impracticable.

Our furnaces will not tap satisfactorily at ratings below 175,000 lb per hr, although they are occasionally tapped at ratings of 150,000 lb per hr.

In normal operation the CO_2 in the furnace is maintained at 14.5 per cent. A lower percentage of CO_2 gives a lower furnace temperature which increases the fuel accumulation in the rear part of the furnace floor. Higher percentages of CO_2 result in overheating of the brickwork above the waterwalls and cause slag to stick to the boiler heating surfaces. When the furnace is being tapped, the CO_2 is raised to 15 per cent to increase the fluidity of the slag. Slag is tapped from each boiler once every 24 hours. The average tapping time is about three hours per day.

Little trouble is now experienced with side and rear waterwall blocks. Occasionally a few blocks burn out on side walls within a foot or two of the slag level because of flame impingement. Considerable trouble is encountered with burning of blocks in the front or burner wall in the first five or six rows from the bottom. Sometimes new blocks installed in this vicinity burn out within six months.

Little trouble has been encountered with slag leaks since installing water-cooled floors. There is no water-cooled side-wall block directly below the slag spout and on a few occasions small amounts of iron sulphide have leaked through at this point near the end of the tapping period when the slag bed is thinnest. No appreciable trouble has recently resulted from growth of the slag bed. The side walls are generally pushed away from the floor blocks a fraction of an inch when the boilers are put on line, but after a period of operation the upper part of the bed becomes molten or plastic, and pressure, exerted against side walls at the slag level by heavy springs, forces the side walls back against the floor blocks. In a few instances it has been necessary to trench the bottom around the side walls to permit the walls to return to their original position, after which the seals are repaired and the trench filled with plastic chrome refractory.

BY H. J. BAUER[2]

In considering the general subject of slag-tap furnaces there are two factors which must be given serious study. The first is the nature of the load carried on the plant and the second is the availability of spare capacity to permit necessary cleaning and repairs to the boilers and furnaces.

A plant having a widely fluctuating load over the day will tend to limit the period for most effective slag removal to those periods of high load. With a base-loaded plant having a high load factor, the removal of ash in a molten state should be simpler; and operating, labor, and furnace-bottom-maintenance costs should be lower than with the so-called dry method of slag removal. Operating for long periods at maximum capacity without slag-tap furnaces requires continual attention to keep ahead of slag accumulations and limits the ash-fusion-temperature range of coals which can be burned with a minimum of difficulty.

The Kip's Bay station of the New York Steam Corporation is equipped with water screens and hoppers for handling ash in the dry form. This is a base-loaded plant and operates at full load from October 1 to May 1. During

[2] General Superintendent Station Operation, New York Steam Corporation, New York, N. Y. Mem. A.S.M.E.

this period, the five boilers have an availability factor of from 95 to 98 per cent and a use factor of 70 per cent.

When No. 5 boiler was installed in 1929 and 1930, serious consideration was given to the installation of a slag-tap furnace. The many advantages of this type of furnace, which were largely as listed by Mr. Shellenberger, had a strong appeal but were not sufficient to outweigh the second consideration mentioned previously, namely, the availability of spare capacity to permit necessary cleaning and repairs to the boilers and furnaces.

This is a particularly important consideration because of the time necessary to enter a slag-tap furnace after the boiler is off the line. If spare units are available and the boiler can be kept out of service for a period of 24 hours or longer for necessary repairs and cleaning, the problem is not so serious. The question of balancing the expected increased efficiency and lower operating costs of slag-tap furnaces against providing spare capacity, either in the same plant or by the operation of less efficient units at some other location, must be determined in making the selection between the two types of installations. The use of the continuous method of removing slag would tend to decrease the time required to enter the furnace because of lesser amounts of molten ash in the bottom, but the actual time required in either case should be carefully considered in making a selection of equipment of this type.

The location of burners at a low point in the furnace and directed at a water-cooled slag bottom would appear to necessitate the starting of units of this type at times when the discharge of unburned carbon from the stack would not be objectionable. When the unit has been brought up to pressure and the slag bed is hot there should be a reduction in combustible loss in the flue gas. The starting-up period, however, may be limited in congested districts to definite periods of the day.

It is our practice to take one of the five boilers in the Kip's Bay station off the line late each Saturday afternoon or during the week as the weather permits. Five to six hours are sufficient to permit any work in the furnaces and as a rule 12 hours from the time the unit is taken out of service is sufficient to make such repairs as are necessary and to clean boiler tubes externally, and also to blow air heaters and turbine economizers. It is doubtful if this program would be possible with a slag-tap furnace. It is only fair, however, to point out that the occasion for entering the furnace is largely to repair brick work, replace bent or damaged screen tubes, and do other work incident to the dry method of handling ash.

Included in the advantages listed by Mr. Shellenberger for the slag-tap bottom is the ability to handle fine ash, soot, and precipitator dust by melting it in the slag bed. In the writer's opinion, this will develop into one of the major advantages for this method of disposing of ash from boilers burning pulverized coal. The difficulty of handling the fine ash is apparent to all who have tried to do it. The usual procedure is to use a wet system. After the ash is wet it tends to remain suspended in the water and it takes a considerable time to settle out. When it has dropped to a point where it can be picked up in a grab bucket it is still a messy and elusive mixture. After being dumped and the moisture evaporated it is easily picked up by a strong wind and carried back in the air in spite of the efforts taken to keep it out of the atmosphere. If a suitable use is not found for these fines to justify their collection and disposal dry, it would seem that the most logical procedure would be to remove them from the gas stream and then convert them in the furnace to a material that can be handled satisfactorily before and after dumping.

BY W. E. CALDWELL[3]

While the slagging bottom is a recent development on a commercial scale, many of the pioneers of pulverized fuel had slagging furnaces, involuntarily, 25 years ago. Much ingenuity was displayed by early inventors in combating the problems of slag and erosion with pulverized-fuel firing in small furnaces. However, slag removal and furnace erosion introduced difficulties which discouraged earlier efforts toward commercial development.

The advent of the waterwall furnace accelerated the progress of pulverized-fuel and slagging furnaces. In 1924, six pulverized-fuel boilers were placed in service in the Sherman Creek station, employing a variety of combustion systems. The furnaces were water cooled, although there was no cooling in the hopper bottoms. From a combustion standpoint these units generally operated quite well after improvements dictated by experience were made.

One boiler which gave the most trouble with furnace slag showed the highest efficiency on test, so the furnace bottom was changed in order that the slag could be withdrawn in a molten state. Slag removal was somewhat crude because of space restrictions, but indicated the attractive possibilities of the method.

Later, a row of boilers was installed at Hell Gate station with direct-fired pulverized-fuel tangential burners. One of these boilers was fitted with a water screen and dry bottom, while another was provided with an air-cooled continuous-discharge slag bottom. The slag opening was made large enough to serve as a means of entry into the furnace, since there was no other convenient point of access. These boilers have been in service several years and the slag-bottom furnace seems to have an advantage over the dry-bottom type, especially in ignition stability at low ratings. The hot bottom maintains strong ignition even with intermittent feeding or unfavorable coal-air ratios, and there have been no "puffs" or explosions in this furnace, such as sometimes occur in the dry-bottom type.

With direct firing, it is difficult on some types of mills to maintain the proper ratio of primary air to coal at all ratings for the best ignition conditions. Since the primary air is used to transport the fuel from the mill to the furnace, this cannot be reduced sufficiently at low ratings to give the desired richness of mixture; otherwise settling takes place in the transport piping. Consequently, the lower the rating the leaner the mixture becomes and the less stable are flame conditions. It has been the writer's experience that under such conditions the slag bottom permits a much lower rating with safety than the dry bottom.

With bin-and-feeder firing there is more flexibility of adjustment of primary air to coal, and in one of our plants using this system we are obtaining satisfactory performance with dry-bottom furnaces.

The continuous slagging furnaces referred to by the author possess some decided advantages. At low ratings there is little or no flow of slag until the bottom accumulates enough refuse to offset the cooling effect of the bottom cooling. At high ratings the reverse is true, and the slag bed thins down to a level which is in equilibrium with the cooling effect in use. The flow of slag is never excessive, since this is established by the rate of melting and depends to a large extent upon the heat input to the furnace.

This system avoids segregation of slag constituents and the enclosed slag cham-

[3] The New York Edison Company, New York, N. Y. Mem. A.S.M.E.

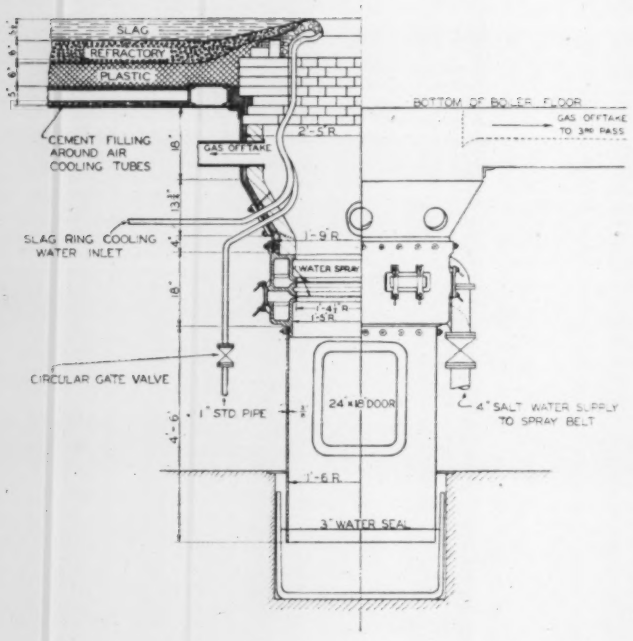


FIG. 1 SLAG-DISPOSAL SYSTEM IN AN EARLY FURNACE DESIGN

ber is a protection against explosions which result from contact of water with slags of high iron-sulphide content. The writer's Fig. 1 illustrates the slag-disposal system of one of the earlier furnaces. One boiler which is provided with this means of slag removal operates about 14 hours daily at moderate rating and is shut down during the midnight watch. Under these conditions there is no difficulty with slag removal with any of the coals which have been used. Air leakage into the furnace is negligible by contrast with that entering through ash-gate leakage in the dry-bottom furnace. This furnace air leakage is an important consideration, especially where high preheat is used, since it by-passes the heat cycle with consequent loss in efficiency.

Our intermittent-tapping boilers have, at times, caused a little difficulty with slag removal, especially in regard to the labor necessary to maintain the slag flow at low ratings. On one boiler the slag spout and receiving end of the sluiceway was enclosed to prevent the entry of air through the slag opening. With the usual slag opening the chilling effect of entering air and water spray is quite obvious. A communicating duct was connected from the slag-tap enclosure to the last pass of the boiler and was provided with a control damper for regulating purposes. By withdrawing furnace gases through the opening, tapping is rendered easier, and practically all of the physical drudgery is eliminated. The arrangement is simple and the principle has considerable promise, especially where coals with high-fusion ash are attractive.

In experiments made with the fusion of fly ash from dust catchers and other sources in the furnace, the greatest problem is the introduction of the material to be fused. Judging from experience, the best results may be expected by introducing the fly-ash in a moistened condition, even approaching a slurry, and the use of sea water for this purpose in our case has a slight advantage in reducing the fusion temperature of the mixture. The fly-ash which is collected by baffles, hoppers, and dust catchers usually has a slightly higher fluid temperature than the furnace slag, due to a selective action within the furnace. The difference should be of little consequence, providing the boiler has adequate slag-removal facilities.

BY R. C. ROE[4]

Experience has shown, as is pointed out in Mr. Shellenberger's paper, that the supporting steel and buckstay steel in furnace bottoms for removing slag in the molten state must be very heavy to insure satisfactory results. The ash or slag bed must be kept thin so that the total stresses on both the supporting and buckstay steel are reduced, particularly on the latter.

Furnaces with refractory bottoms have failed in many cases, particularly those of the early designs, but in some cases they have not failed. This perhaps is true particularly of the later designs. The difference between failure and non-failure of this type of bottom, apparently, is caused by the difference in the fuel supply and in the burner. It does not necessarily follow, therefore, that all furnace bottoms of the molten-ash type have to be water cooled, although this undoubtedly is a wise precaution to take in most cases. Several refractory-bottom furnaces are in successful use which at this writing have been in service long enough so that it can be said with reasonable certainty that they will not fail if their operation is continued with the same coal and burners which have been used since their original installation.

With coals containing sulphur or sulphur with iron pyrites, it is important that the furnace bottom not only be supported properly both as to the weight and from a thrust viewpoint, but also that care be taken in operation so that a boiler is never cooled with a thick ash bed or, if so cooled down, that steps be taken to relieve the pressure before re-starting. In fact, at some plants it is standard practice to relieve the pressure by cutting a cross in the furnace bottom every time the furnace has cooled down sufficiently. This procedure is not expensive and it seems to be beneficial in reducing the effects of side-wall thrusts.

The paper points out the tendency toward down-shot turbulent-type burners. Whereas this is perhaps an advantage from the viewpoint of fluidity of the molten ash, it is also a distinct disadvantage, in some cases at least, because the impurities in the ash, consisting mainly of iron and sulphur, reach the ash bottom before sufficient time has elapsed for oxidation. The writer is convinced that it would be desirable if possible to segregate coarse particles of pulverized coal and so to place them in the furnace that the maximum possible time is obtained in the oxidizing flame of the furnace before these particles finally reach the ash bed.

As an illustration of this, in a plant with three boilers, all of which were originally equipped with refractory furnace bottoms or bottoms of similar type, two boilers were equipped with burners which naturally tended to segregate the heavy portion of pulverized fuel in a zone which allowed comparatively short travel between the burner and the ash bed. These two boilers had furnace failures within a few months of their starting operation. The third boiler was equipped with burners which tended to segregate the coarse particles of the pulverized fuel and pass them to the furnace in an upward direction, allowing them to enter the furnace 10 or 12 ft above the ash bed, thereby permitting a long path in the furnace for these heavy particles before reaching the ash bed. This boiler has been in operation for nearly five years and still has its original bottom. This experience indicates, perhaps conclusively, that the distribution of the coarse particles of pulverized fuel in the furnace has a distinct bearing on furnace stresses and life. Therefore, it would seem to follow logically that the type

[4] Engineering Consultant, Burns and Roe, Inc., New York, N. Y.

of burner which permits the longest retention of these particles for oxidation purposes in the furnace is the one which will produce the least stress on the furnace bottom.

Mr. Shellenberger's comments in regard to fine pulverization are noted. In most cases, the writer believes it is a mistake, particularly with molten-ash furnaces, to use a type of pulverizer not capable of producing fine pulverization. Preference certainly should be given to one capable of producing a fineness where at least 80 per cent will pass through a 200-mesh screen.

In addition to fine pulverization it is desirable, as brought out in the paper, to use highly preheated air. It is believed that with the molten-ash type of furnace this is not only desirable but a ready means of increasing combustion efficiency if the hottest possible air is used. The limitations on preheated-air temperatures are not entirely economic but to a degree are controlled by the material available at reasonable cost for heater parts, ducts, wind boxes, and burner parts. The benefits derived in combustion would seem to warrant the general practice of higher air temperatures.

The comments in the paper about burners which are designed so that they will be self-cooling when idle cannot be overemphasized. It would appear desirable in most large furnaces to install several burners of this type.

Experience with water-cooled liners on the ash-tap spouts has been favorable, and the writer believes them to be a distinct advance in the art.

The points brought forth in the paper about the cooling of tapered temperature zones as the gases approach the boiler convection surface cannot be overemphasized. It would seem desirable in the future to carry this type of design still further.

Note is made of the examples of the furnaces given by the author, indicating that the tendency is greatly to increase furnace liberations. This tendency is a correct one but should be accomplished only as combustion conditions and burner designs improve. There is altogether too much of the present furnace volume used as a mixing chamber to make up deficiencies which should be accomplished in the burner.

The tendency toward the use of highly turbulent burners, higher air temperatures, and quicker and more complete combustion should permit lowered furnace volumes and hence higher liberation, and should point toward greater use of the molten-ash type of furnace bottoms.

BY H. G. THIELSCHER[5]

The Buzzard Point plant of the Potomac Electric Power Company was started in November, 1933. The furnace arrangement is shown in Fig. 3 of the author's paper.[1]

Experience to date supports the author's conclusion that a bottom-supported furnace can be constructed to withstand successfully the expansion stresses imposed on it, that it can be kept free of slag leaks, and that it can be operated with a minimum of maintenance of furnace parts exposed to the slag and flame action. The author mentions the elimination of maintenance on water-cooled slag-spout liners. The average life of our monel-metal slag-spout liners is one year. There is some wasting away of the cast-iron blocks on the vertical walls at the slag line, but this is fairly slow.

We have burned coal from the West Virginia and Virginia fields exclusively, coming from the Pocahontas No. 3, No. 5, and Sewell seams. This coal runs about 20 to 23 per cent volatile, 6 per cent ash, and 0.6 to 0.7 per cent sulphur.

The author refers to ash-fusion temperature as a criterion of suitable coal for slag tapping. Some coals have a greater spread than others between the ash-fusion and ash-fluid temperature, consequently one may be misled if suitability is judged solely by ash-fusion temperature. With coal, the ash-fluid temperature of which is below 2500 F and above 2300 F, the writer has noted a marked difference in rate of tapping and also in conditions on the slag screen and boiler heating surfaces. Where one coal gives good results, another will be unsatisfactory in rate of slag flow, slag accumulation on slag screen, and slagging of boiler tubes. The writer's company has selected coal on the basis of ash-fluid temperature as an index factor with respect to satisfactory flow rate from the furnace. There is another factor which is not defined by any present-day tests and for want of a better name the writer calls it viscosity. Coals with approximately the same ash-fusion and ash-fluid temperatures act differently in so far as speed of tapping is concerned and also in regard to their adherence to slag-screen and boiler-heating surfaces.

The writer has found that coals having an ash-fluid temperature in excess of 2500 F are unsatisfactory because of inability to tap and because of excessive formation on the slag or dust screen to the point where it becomes closed to the flow of gases.

The Buzzard Point units are tapped from the center of the rear of the furnace. Later experience indicates the side location is preferable because it is hotter than the rear location.

After taking a boiler off the line, the writer has found an accumulation of iron in the furnace bottom which can be removed only by cutting with an electric arc. This is a slow and expensive process.

The author states: "Wide flexibility and ease of tapping are possible with units of modern design." The Potomac Electric Power Company has units two years old which must be operated at 80 per cent of designed maximum boiler output before they can be tapped with any degree of ease. The writer believes a satisfactory installation should permit tapping down to at least 50 per cent of maximum, and when one considers that the base-load unit of today is the peak-load unit of tomorrow, it would appear that even a wider range than this is necessary.

The question of returning fly ash to the furnace brings up the point as to whether this material would not be of a higher fusion temperature and interfere with tapping. The writer would be interested to hear of any actual experience with this practice.

Comparison of the furnaces at Richmond, shown in Fig. 5 of the paper, with those at Buzzard Point are significant in that the heat release per foot of front width is 18 per cent higher at Richmond and the heat release in the volume below the slag screen 100 per cent higher. Observation of operating conditions indicates that a wider range of load is permissible with satisfactory tapping and the use of fuel with a higher ash-fluid temperature.

BY H. DRAKE HARKINS[6]

The writer is in agreement with the conclusions reached by Mr. Shellenberger. The ideal boiler furnace should be (1) reasonable in first cost, (2) efficient in operation, (3) adaptable to a variety of cheap fuels, (4) continuous and reliable in operation, (5) quickly accessible for repairs, and (6) low in maintenance cost.

While by no means universal in its application, the intermittent slag-tap furnace probably approaches more nearly the ideal than any other boiler furnace. However, the writer wishes to discuss

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[6] Industrial Engineer, E. I. du Pont de Nemours and Company, Inc., Wilmington, Del. Mem. A.S.M.E.

only (1) first cost and (2) reliability and continuity of operation.

In making comparative estimates, the writer has found that in units of capacities greater than 70,000 lb of steam per hr the slag-tap steam-generating unit is cheaper in first cost than the dry-bottom type. The slag-tap unit requires between 10 to 15 ft less building height. This not only reduces building cost, but also reduces the cost of wiring, piping, ducts, and other items which extend throughout the building. The writer recently applied an inexpensive slag-tap machine to a boiler furnace. This further reduces cost, as the machine is quite inexpensive in comparison with the cost of hydraulic quenching and transport systems previously used.

Continuity of steam and electrical supply is vital to many industries. Perhaps the outstanding advantage of manual or machine-stoked fires is the large ignited fuel bed which is available in emergency. Any such stabilizing factor is notably absent from the modern, completely waterwalled, dry-bottom pulverized-coal furnace. It sometimes happens that a partial interruption of fuel feed, such as the stopping of one mill (or feeder), will result in total loss of the fire. The writer has made inquiries at several plants and has reached the tentative conclusion that such interruptions, while not unknown, are less frequent in the intermittent slag-tap furnace because of the stabilizing and ignition effect of the mass of molten slag. Because of this stabilizing influence, the writer favors the intermittent over the continuous slag-tap furnace.

BY A. B. CLARK[7]

Most of the writer's experience has been with slag-tap furnaces burning coals high in ash content and containing a considerable amount of iron pyrites. Consequently, the troubles developed with the slag-tap furnaces with which the writer has been familiar have been due to this element. The usual expansion of the slag bed and troubles with the side walls have been experienced, together with the attack of the iron sulphide on the furnace-floor tubes.

In the furnaces referred to the superheated iron sulphide is particularly viscous and has led to the consideration of continuously tapping out the slag so that pools of sulphide cannot be formed. The writer has knowledge of an intermittent slag-tap furnace which has been changed over to provide for continuous tapping by replacing about six tubes in the furnace floor with new ones bent to form a tap hole through which the slag might drain. The slag falls through a brick-lined chute into a tank of water which will hold about a day's run of slag. The granulated slag is easily removed from the tank into the sluice system.

As is often the case in experiments of this nature, existing conditions limited the design, and it was found that the tap hole was too large in relation to the brick-lined chute and the slag would be carried over to the side, stick, and build up. This condition was remedied by reducing the size of the tap hole by inserting a water-cooled ring; however, the cold house-service water used to cool the ring caused it to corrode badly on the outside due to the slag. This condition was not experienced when the tap-hole tubes were connected to the boiler circulation and therefore were at the saturated-steam temperature. A separately cooled ring such as described would probably be satisfactory with a less corrosive slag.

For use with highly corrosive slags, the writer believes that the furnace bottom should be effectively water-cooled and sufficiently sloped to a point where the slag can be tapped out continually in some such manner as previously mentioned. There are many practical advantages to such an arrangement; there is no hazard in its operation, little attention is required, the granulated slag is easily run out of the tank in a few minutes, the removal is clean and free from dust.

BY M. K. DREWRY[8]

General advantages of slag-tap furnaces should not be listed without treating their effect upon performance past the furnace outlet. There is need for a paper which would give data relative to long-time maintenance of acceptable uniform cleanliness of boiler and superheater surfaces in which variable conditions of ash fluidity and solidity occur.

High temperatures of slag-tap furnaces are claimed to assist combustion rapidity and completeness. An A.S.M.E. paper[9] by E. H. Tenney gives data and references indicating the opposite effect.

Higher steam temperatures accentuate the need of uniform superheat control. How widely varying degrees of furnace and slag-screen cleanliness can permit uniform steam temperatures is not readily apparent.

Insulating expensive radiant-heat-absorbing surfaces or attaching appendages which collect various amounts of insulating ash, has never seemed economical. The writer does not agree that ash removal from the furnace bottom is a vital factor dictating entire boiler-unit design.

[7] Sargent and Lundy, Inc., Engineers, Chicago, Ill. Mem. A.S.M.E.

[8] Assistant Chief Engineer of Power Plants, The Milwaukee Electric Railway and Light Company, Milwaukee, Wis. Mem. A.S.M.E.

[9] "Pulverization and Boiler Performance," by E. H. Tenney, Trans. A.S.M.E., vol. 54, 1932, paper FSP-54-7, pp. 55–65.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideraton. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following are records of the interpretations of this Committee formulated at the meeting of March 27, 1936, and approved by the Council.

CASE NO. 820

(Special Ruling)

Inquiry: The maximum allowable working pressures permitted by the application of the formulas in Tables P-2, P-3, P-4, and P-5 for thicknesses of boiler and superheater tubes, result in many odd values. May not these values of maximum allowable working pressures be rounded out for practical use?

Reply: It is the opinion of the Com-

mittee that, in view of the consideration being given to the revision of tube tables, the values of the maximum allowable boiler pressures in pounds per square inch only, resulting from the application of the several formulas for boiler and superheater tubes, may, for actual use, be increased to the nearest larger value which is a multiple of ten.

CASE No. 821

(Interpretation of Par. P-302)

Inquiry: Previous to the last revision of Par. P-302 of the Code, it was stipulated that where the pressure exceeded 125 lb in the steam mains, extra-heavy construction (250 lb) was to be used. Please explain the revision, also whether it is the intent that 100 lb was to be the line of demarcation on steam mains as well as blow-offs, and if extra-heavy construction (250 lb) was to be used when that pressure was exceeded.

Reply: When the Code was first written, the only fitting standards were those for 125-lb and 250-lb cast iron—commonly designated as "standard" and "extra-heavy" and so used in the Code. The steel-flange standards later adopted and issued were included in the Code but without direct reference in the several appropriate paragraphs to their use. The several revisions were made for the purpose of clarifying the use of the cast-iron and steel fittings without changing essentially the use of the cast-iron fittings but eliminating the terms "standard" and "extra-heavy" which are no longer distinctive.

It was the intent of the Committee that valves of intermediate standards between 125-lb and 250-lb pressure which have their pressure ratings plainly marked on the valves, may be used for steam service up to their rated capacity and for all feed-line service subject to all restrictions of the Code as to temperature and pressure for the particular service.

It was the intent of the Code revision to allow the full use of the steel standards listed for steam service at any adjusted pressure-temperature rating given in Table A-10.

The requirement that valves and fittings on water lines below the water line, which includes all boiler-feed lines and blow-off service, up to and including the required valve or valves, shall be suitable for pressures 25 per cent in excess of the maximum allowable boiler pressure is to make allowance for the actual increased pressure or shock due to temperature conditions in service. The line of demarcation at 100-lb pressure for 125-lb cast-iron fittings for feed line and blow-off services arises from this restriction which was not intended to be applied to steam mains.

CASE No. 822

(In the hands of the Committee)

CASE No. 823

(Special Ruling)

Inquiry: Is it permissible, in the construction of low-pressure heating boilers, to use a dished head, having no knuckle flange, secured to the shell by a corner weld? Also, what rule must be followed in making the welded-head attachment?

Reply: It is the opinion of the Committee that this construction may be used provided the welding of the head to the shell conforms to Par. H-78, except that hot-water boilers and boilers built for domestic water supply above 30-lb pressure shall be constructed with flanged heads.

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PARS. P-1 and U-12. Insert the following as (*c*) of these paragraphs:

Cast, forged or rolled parts of small size or which are ordinarily carried in stock and for which mill test reports or certificates are not customarily furnished may be used provided it has been demonstrated that they are suitable for the purpose intended.

PAR. P-9. Revise first sentence to read:

When the maximum allowable working pressure (See Par. P-179) exceeds 160 lb per sq in., cross-pipes . . . . shall be of wrought steel or cast steel [of Class B grade as designed] in ACCORDANCE WITH Specifications S-11 [for Carbon Steel Castings] OR S-12.

PAR. P-11. Revise to read:

P-11. Pressure parts of superheaters separately fired or attached to stationary boilers, unless of locomotive type, shall be of wrought steel, puddled or knobbled charcoal wrought iron, or cast steel AS DESIGNATED IN SPECIFICATIONS S-11 OR S-12, OR ALLOY PIPE AS DESIGNATED IN SPECIFICATIONS S-33 (A.S.T.M. A 157), OR ALLOY STEEL CASTINGS AS DESIGNATED IN SPECIFICATIONS S-34 (A.S.T.M. A 158) [of Class B Grades as designated in the specifications.]

PARS. P-103*a* and U-71*a* Add the following sentence:

All vessels constructed of plate conforming to Specifications S-26 and S-27, with or without the addition of molybdenum, shall be radiographed and stress relieved.

PARS. P-103*b* and U-71*b*. Modify proposed revision appearing in the May, 1936, issue of MECHANICAL ENGINEERING to read as follows:

b Material for manhole frames, nozzles and other pressure connections which are to be joined to the shell or heads by fusion welding shall, when forged or rolled OR CAST comply with the specifications given for [shell] plates [and heads FORGINGS OR CASTINGS AS TO chemical and physical properties and be of good weldable quality. [Cast steel or wrought steel nozzles may be used only when the material has been proved to be of good weldable quality. The carbon content in all such material shall not exceed 0.35 per cent.] SMALLER PARTS OF CAST, ROLLED, OR FORGED STEEL OF GOOD WELDABLE QUALITY MAY BE USED AS PROVIDED FOR IN PAR. P-1*c* (U-12*c*).

PAR. P-293. Revise first sentence to read:

When shut-offs are used on the connections to a water column, they shall be either outside-screw-and-yoke OR LEVER-LIFTING type gate valves or stop cocks with levers permanently fastened thereto and marked in line with their passage, etc.

PAR. P-299*d*. Revise to read:

d All valves and fittings on ALL FEED WATER PIPING AND WATER PIPING [water lines] below the water line shall be equal at least to the requirements of the American Standards for a pressure 25 per cent in excess of the maximum allowable working pressure [except that for pressure over 100 lb per sq in., they shall be equal at least to the requirement of the American Standard for 250 lb per sq in.]

CAST-IRON VALVES OF INTERMEDIATE STANDARDS BETWEEN 125 LB AND 250 LB PRESSURE WHICH HAVE THEIR PRESSURE RATINGS PLAINLY MARKED ON THE VALVES MAY BE USED FOR THIS SERVICE UP TO 80 PER CENT OF THEIR RATED VALUE.

PAR. P-299*e*. Insert the following as the second section:

VALVES AND FITTINGS OF STEEL CONSTRUCTION EQUAL TO THE AMERICAN STANDARDS GIVEN IN TABLE A-6 MAY BE USED FOR MAXIMUM ALLOWABLE BOILER PRESSURES WHICH HAVE BEEN ADJUSTED AS FOLLOWS:

PRESSURES GIVEN IN AMERICAN STANDARDS FOR 750 F

100 300 400 600 900 1500

MAXIMUM PRESSURES AT WHICH BOILERS CAN BE OPERATED WHEN USING THE ABOVE STANDARD FLANGED FITTINGS OR VALVES FOR FEED AND BLOW-OFF SERVICE UNDER THIS PARAGRAPH AND PAR. P-310.

150 320 420 610 900 1400

PAR. P-302. Add the following:

CAST-IRON VALVES OF INTERMEDIATE STANDARDS BETWEEN 125 LB AND 250 LB PRESSURE WHICH HAVE THEIR PRESSURE RATINGS PLAINLY MARKED ON THE VALVES MAY BE USED FOR STEAM SERVICE UP TO THEIR RATED CAPACITY SUBJECT TO THE RESTRICTIONS OF PAR. P-12.

PAR. P-310. Revise (*d*) to read:

d For pressures exceeding 100 lb per sq in., the valves and fittings shall [be equal at least to the requirements of the American Standards given in Tables A-8 and A-11 in the Appendix for 250 lb per sq in.] IF OF CAST IRON, BE EQUAL AT LEAST TO THE REQUIREMENTS OF THE AMERICAN STANDARDS FOR 250 LB AS GIVEN IN TABLES A-8 AND A-11; AND IF OF STEEL CONSTRUCTION SHALL BE EQUAL TO THE REQUIREMENTS OF THE AMERICAN STANDARDS AS GIVEN IN TABLE A-6, SUBJECT TO PAR. P-299*e*.

In (*e*), revise reference to "250 lb" to read "200 lb."

PAR. A-19. Modify proposed revision appearing in the April, 1936, issue of MECHANICAL ENGINEERING to read:

A-19 *a*. Fire-actuated fusible plugs, if used, shall be filled [from the water side and to the point of least diameter of the hole in the casing] with tin of the following composition, having a melting point of between 400 and 500 F.

Pure tin, minimum, per cent	99.3
Copper, maximum, per cent	0.5
Lead, maximum, per cent	0.1
Total impurities, per cent	0.7

b THE FUSIBLE METAL SHALL EXTEND FROM THE WATER END OF THE PLUG TO THE POINT OF LEAST DIAMETER OF THE HOLE and [The filling] shall be carefully alloyed TO [with] the casing. TEST SHALL BE MADE TO DETERMINE THAT THE FUSIBLE METAL IS NOT LOOSE IN THE PLUG.

c The fusible plug shall be renewed at least once each year.

d When the boilers are operated at working pressures in excess of 250 lb per sq in., the use of fusible plugs is not advisable.

PAR. A-20. Modify proposed revision appearing in the April, 1936, issue of MECHANICAL ENGINEERING to read:

A-20 *a* Water-side plugs are fusible plugs which are inserted from the water side of the plate, flue, or tube to which they are attached. Fire-side plugs are fusible plugs inserted from the fire side of the plate, flue, or tube to which they are attached.

b The casing of the fusible plugs shall be made of bronze of the following composition:

	GRADE B	GRADE C
Copper, minimum, per cent	84	86
Tin and Zinc, combined,[1] min, per cent	9	10
Lead, maximum, per cent	2.5	0.3

[1] Note: Zinc and lead may be reduced or eliminated if replaced by copper and tin.

c TYPICAL DESIGNS OF FUSIBLE PLUGS ARE GIVEN IN [The design of the easing shall be in accord with] Fig. A-10.

d The bore of the casing shall be tapered continuously [and evenly] from the water end of the plug FOR A DISTANCE OF AT LEAST 1 INCH to a diameter of not less than $\frac{3}{8}$ in. [at a point $\frac{1}{2}$ in. from the fire end.] The diameter of the bore ON THE WATER [at either] END shall not be less than $\frac{1}{2}$ in. THE HOLE ON THE FIRE SIDE OF THE FUSIBLE PLUG SHALL BE AS LARGE AS POSSIBLE AND MAY BE OF ANY SIZE OR SHAPE PROVIDED THE CROSS-SECTIONAL AREA AT ALL POINTS IS GREATER THAN THE AREA OF THE LEAST CROSS SECTION OF THE FUSIBLE METAL.

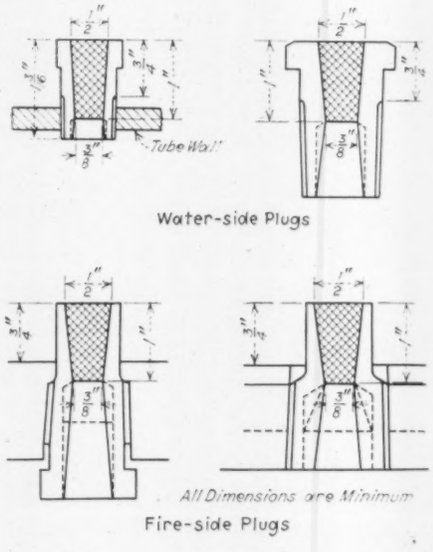


FIG. A-10 TYPICAL FORMS OF FUSIBLE PLUGS

e A fusible plug shall be of such length that when installed it shall project at least $\frac{3}{4}$ [1] in. on the water side of the plate, tube, or flue and [as little as possible but not more than $\frac{1}{2}$ in. on the fire side. If a fire-actuated fusible plug is inserted in a tube, the tube-wall shall be not less than 0.22 in. in thickness or sufficient to give four full threads.] IT SHALL EXTEND THROUGH THE PLATE, TUBE, OR FLUE ON THE FIRE SIDE AS LITTLE AS POSSIBLE BUT NOT MORE THAN $\frac{1}{2}$ IN.

f A FIRE-SIDE PLUG MAY BE DESIGNED SO AS TO BE INSERTED BY MEANS OF A PLUG TYPE WRENCH, SO AS TO REDUCE THE PROJECTION ON THE FIRE SIDE.

g THE MINIMUM LENGTH OF A FUSIBLE PLUG CASING SHALL BE $1\frac{7}{16}$ IN.

h IF A FIRE-ACTUATED FUSIBLE PLUG IS INSERTED IN A TUBE, THE TUBE WALL SHALL NOT BE LESS THAN .22 IN. THICK, OR SUFFICIENT TO GIVE FOUR FULL THREADS.

i FUSIBLE PLUGS WHICH COMPLY WITH THE REQUIREMENTS OF PARS. A-19 AND A-20 MUST BE STAMPED ON THE CASING WITH THE NAME OF THE MANUFACTURER, AND ON THE WATER END OF THE FUSIBLE METAL "A.S.M.E. STD."

Table A-10. Proposed addition published in April, 1936, issue of MECHANICAL ENGINEERING rescinded.

PAR. L-10. Revise first sentence to read:

L-10. Water-leg and door-frame rings shall be of wrought iron or steel, or cast steel IN ACCORDANCE WITH SPECIFICATIONS S-11 [of Class A or Class B grade as designated in the specifications.]

The following table is the recommendation of the Subcommittee on Ferrous Materials:

ALLOWABLE STRESSES AT ELEVATED TEMPERATURE FOR STEEL PLATE[1]

	Temp., F	S-1(A-70) Flange, firebox	S-1(A-70) Killed firebox	S-26 (A-149) S-27 (A-150) Grade A firebox	S-26 (A-149) S-27 (A-150) Grade B firebox	S-26 (A-149) S-27 (A-150) Grade A firebox .40–.60 Molyb.	S-26 (A-149) S-27 (A-150) Grade B firebox .40–.60 Molyb.
Flange and Firebox	650	11000	11000	13000	14000	13000	14000
	675	10800	10800	12760	13680	13000	14000
	700	10400	10400	12160	12840	13000	14000
	725	9800	9960	11280	11640	13000	14000
	750	9240	9480	10400	10560	13000	14000
	775	8640	8960	9560	9560	12870	13780
	800	8000	8440	8800	8800	12400	12800
	825	7320	7880	8000	8000	11630	11800
	850	6680	7240	7240	7240	10800	10800
Firebox Only	875	5920	6560	6560	6560	9750	9750
	900	5120	5800	5800	5800	8720	8720
	925	4200	4920	4920	4920	7770	7770
	950	3200	4000	4000	4000	6800	6800
	975	....	3200	3200	3200	5800	5800
	1000	....	2400	2400	2400	4800	4800

NOTE: Spec. S-1, killed, silicon = 0.15 to 0.25 per cent; Spec. S-26 and S-27, minimum silicon = 0.15 per cent.

[1] If no objections are received to this table it will be used as a basis for revising Table P-8.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Liberal Tradition

THE LIBERAL TRADITION. By Lewis W. Douglas. D. Van Nostrand Co., New York, N. Y., 1935. Cloth, 5.5 × 8.5 in., 136 pp., $1.50.

REVIEWED BY E. DILLON SMITH[1]

THIS is an amazing book. It was written by the former director of the Bureau of the Budget, a man who was for a long time closely associated with President Roosevelt. Through this relationship Douglas has had much practical experience with the financial policies of the government. In the main, the book is in open opposition to the New Deal.

This challenging analysis of some of the vital issues before the American people, a balanced budget or inflation and the constitution or dictatorship, was presented as the Godkin Lectures at Harvard University in May of 1935. In particular, Douglas is critical of the fiscal policies of the Administration and feels that the tendency toward a planned economy creates a serious threat to our traditional form of government, as well as the social and economic welfare of the people.

The book is divided into four parts: (1) The sins of the past; (2) a planned economy and the oppressive state; (3) dictatorship and a fiscal policy; and (4) a free people and a free economy. In the preface, the author mentions some of the events of historic interest that have occurred since the lectures were delivered; the unanimous decisions of the Supreme Court in the cases of Commissioner Humphrey of the Federal Trade Commission and the A. L. A. Schechter Poultry Corporation.

The author expresses simply and directly a point of view which he believes to be gradually disappearing from human consciousness, and is aware that his utterances may not be popular with any group. He feels that few men seem to be able to contemplate calmly the turmoil of a confused world. As he puts it, man "has demonstrated many times before his peculiar ability to lose his sense of proportion, and to forget that the only characteristic which distinguishes him from other forms of animal life is his alleged power to think."

The "sins of the past" shows, in rather broad outline, the economic acts that have been committed in the past and those which should be avoided in the future. Four dominant characteristics and fallacies are disclosed: (1) High tariffs destroyed competition in the creation of an economic order that could not sustain the shock. (2) The tariff policy lead to the government sanction of illegal price fixing, "or an indifference on the part of the federal government to the provisions of the Sherman Anti-Trust Laws." (3) The Banking Act of 1927 was a contributing forerunner of the depression and in turn lead to an ill-advised managed currency which ultimately results in cheap money. The situation is further complicated by a creditor nation's gold movements and tariff policies. (4) Rigidities crept into the economic system by making the cost of capital an unalterable cost of production. This was brought about by the cheap-money fiscal policy that encouraged the incurrence of excessive debt not only by individuals but by corporations.

"A planned economy and the oppressive state" distinguishes between the confusion of the hectic post-war period and the initial stages of the depression. In some cases the confusion is ignorance, in others it is deliberate design. Regardless, "many confuse the system which failed for the competitive (orthodox economic) system for profit, and they substitute a social and economic system completely new to America for the one under which we have grown great." The important controversy to the author is that the present system has a capacity for more production than is consumable (at a price) under the same system that shortens purchasing power as it lengthens its capacity to produce. But, "as often as the proposition has been argued, so often has experience demonstrated the proposition to be wrong." Much is said about the socialists and communists, and the "collective state—a planned economy." From a purely economic viewpoint the author seems a little weak when discussing these several types of economic systems; however, the presentation stimulates thought—especially with regard to cotton and unemployment.

"Dictatorship and a fiscal policy" presents the social and economic consequences of government's power to appropriate and expend money, and its power to make money. The difference between a corporation and a bankrupt government is discussed. In the latter case, "the most modern expedients [are] to compel the commercial banks to take government obligations, to set up on their books a credit against which the government may draw its' checks."

In "a free people and a free economy" criticism of the Administration is dropped and consideration is given to the alternatives which the nation now faces: State ownership—a static society and tyranny which becomes stagnated—or "private ownership of property—a progressively rising standard of living, a competitive society, and freedom from the other." To gain the latter objective, "the postulates to a smoother working of a liberal economy are: First, free competition and flexibility of prices; second, mobility of labor and of goods; third, flexibility of costs; fourth, a modification of our tariff policy to effect and maintain (*a*) a balance between agriculture and industry, (*b*) a sound currency, and (*c*) escape from despotism; fifth, a greater use of the 'Compact Clause' of the Constitution and a greater exercise of local responsibility; sixth, a reformed banking system; and finally, a responsible fiscal policy which will assure stability of exchanges."

The book reveals a deep and disturbing liberal tradition. Regardless of one's political or economic beliefs, much may be gained by reading Mr. Douglas' book.

[1] Member, A.S.M.E. Economics Committee. Economics and Industrial Administration, Pratt Institute, Brooklyn, N. Y.

Books Received in Library

AMERICAN PETROLEUM INDUSTRY, a Survey of the Present Position of the Petroleum Industry and Its Outlook Toward the Future. American Petroleum Institute, New York, 1935. Cloth, paper, 6 × 9 in., 229 pp., tables, $1; $0.50. This work has been prepared by the American Petroleum Institute to meet the need by the public for an authoritative description of the petroleum industry. Chapters on demand, production and supply,

transportation, refining, marketing, taxation, and labor have been prepared by committees of experts in those fields. The volume provides an excellent survey of the industry as it affects our national life.

BIBLIOGRAPHY OF AERONAUTICS, 1932. U. S. National Advisory Committee for Aeronautics, Washington, D. C., 1936. Cloth, paper, 7 × 10 in., 296 pp., $1; $0.50. The bibliography lists, by author and subject, the books and articles published during 1932. All the important periodicals in the field are included, together with the publications of the various government air services, etc.

DAVISON'S RAYON AND SILK TRADES, the Standard Guide, 41st Annual, 1936, Pocket edition. Davison Publishing Co., New York. Leather, 5 × 8 in., 600 pp., illus., $5.50. This standard guide provides an annual directory of those engaged in these trades as manufacturers, distributors, and users, as well as to manufacturers and dealers in machinery and supplies.

ENGLISH IN BUSINESS AND ENGINEERING. By B. W. Stevenson, J. R. Spicer, E. C. Ames, and C. F. Kettering. Prentice-Hall, New York, 1936. Cloth, 6 × 9 in., 365 pp., diagrams, charts, maps, tables, $2.25. This book provides a practical course in English for college students, and also a useful reference book for the professional engineer and business man. The writing of letters and articles, public speaking, and the elements of grammar and logic are combined in a sensible, practical manner. Common faults are discussed and correct expression is emphasized.

FORSCHUNGSHEFT 377. SPEKTRALUNTERSUCHUNG DES VERBRENNUNGSVORGANGES ZUR UMSETZUNG IN TECHNISCHEN FLAMMEN, by G. Beck; Verbrennung in Dieselmotor, by C. Erichsen. V.D.I. Verlag, Berlin. Paper, 8 × 12 in., 31 pp., illus., diagrams, charts, tables, 5 rm. The two investigations recorded in this number throw new light upon the decomposition of liquid fuels in flames and especially upon the process of combustion in the Diesel engine. Dr. Georg Beck studied the phenomena of combustion in gas oil, benzol, and other liquid fuels by pyrometric, analytic, and spectroscopic methods, and showed the advantages of the last method. Dr. Erichsen applied the spectroscopic method to combustion in the Diesel engine.

GLANCES AT INDUSTRIAL RESEARCH during Walks and Talks in Mellon Institute. By E. R. Weidlein and W. A. Hamor. Reinhold Publishing Corporation, New York, 1936. Cloth, 5 × 8 in., 246 pp., illus., $2.75. In a readable, nontechnical way this book explains to the business man how industrial research is conducted at the Mellon Institute, tells something of recent achievements, and suggests future opportunities.

HIGH-SPEED DIESEL ENGINES. By J. Vanderdoes, L. H. Morrison and C. T. Baker. International Textbook Co., Scranton, Pa., 1936. Leather, 5 × 8 in., diagrams, $1.80. The first part of this book discusses the principles of these engines. The second part describes the construction and operation of truck, tractor, and locomotive engines.

INTRODUCTION TO PHYSICAL METALLURGY. By L. R. Van Wert. McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 272 pp., illus., diagrams, charts, tables, $3. The fundamental principles of the subject are presented concisely and clearly in this textbook, which is based upon the author's lectures at Harvard University. The work aims to be interesting and comprehensive enough for those who seek only a general knowledge of the subject, and sufficiently specific and fundamental to be a satisfactory introduction for those who intend to continue in the study.

Introduction to the Metallurgy of IRON AND STEEL. By H. M. Boylston. Second edition. John Wiley & Sons, New York, 1936. Leather, 6 × 9 in., 563 pp., illus., diagrams, charts, tables, $5. A comprehensive outline of the subject is provided in this work, which presents the fundamentals of iron and steel making in a simple, straightforward manner. The book should be useful as a handy reference book on general principles, as well as a convenient text for students. The new edition has been revised as to statistics, and the Byers-Aston process, the continuous sheet mill, and other new developments in the industry have been added.

JAHRBUCH DER BRENNKRAFTTECHNISCHEN GESELLSCHAFT e. V. Vol. 16, 1935. Wilhelm Knapp, Halle (Saale), 1936. Paper, 7 × 11 in., 100 pp., illus., diagrams, charts, tables, 9.70 rm. (7.25 rm. in U. S.). This volume contains the papers and discussions presented at the joint meeting of the Brennkrafttechnische Gesellschaft and the Deutsche Gesellschaft für Mineraloelforschung in December, 1935. The meeting was devoted to a discussion of developments in automobile and airplane engines. Papers on airplane Diesel engines, Diesel-engine fuel supply, pulverized-coal engines, carburetor engines, ignition and sparkplugs, and other related topics are included.

JOB HUNTING AND GETTING. By C. Belden. L. C. Page & Co., Boston, 1935. Cloth, 6 × 9 in., 297 pp., $2.50. This is practically a textbook on the art of seeking employment. It suggests concrete ways and means of conducting a systematic campaign for a position which should be helpful to the man in search of one or of a more desirable one. The material is based upon the experience of the author and his friends.

KEMPE'S ENGINEER'S YEAR-BOOK of Formulae, Rules, Tables, Data, and Memoranda for 1936, a Compendium of the Modern Practice of Civil, Mechanical, Electrical, Marine, Gas, Aero, Mine, and Metallurgical Engineering. Forty-second annual issue, revised under the direction of L. St. L. Pendred. Morgan Brothers, London, 1936. Leather, 5 × 7 in., 2664 pp., illus., diagrams, charts, tables, 31s 6d. The 1936 edition of this well-known reference book shows no marked change from previous ones, but has undergone the customary careful revision by a large corps of competent specialists. A new section on acoustics has been added. The book covers a wider field than any other work of the kind, and is admirably adapted to the day-by-day needs of the practicing engineer.

DIE KORROSION DES EISENS UND SEINER LEGIERUNGEN. (Die Korrosion metallischer Werkstoffe, Bd. 1) edited by G. Masing, E. H. Schulz, C. Carius, K. Daeves, E. Houdremont, H. Schottky. S. Hirzel, Leipzig, 1936. Paper, 7 × 10 in., 560 pp., illus., diagrams, charts, tables, 39 rm. This is the first of four volumes which are designed to provide a comprehensive, critical review of our knowledge of the corrosion of metals, considered in the light of modern theoretical views. The present volume opens with a discussion of the theory of corrosion, by Dr. Masing. The remainder of the volume is devoted to the corrosion of iron and steel. Dr. Carius and Mr. Schulz describe ferrous corrosion in general, Dr. Daeves contributes an article on corrosion-resisting iron and steel, and Dr. Houdremont and Dr. Schottky discuss the corrosion and heat-resisting alloys of iron.

DAS KRAFTFAHRZEUG, Betriebsgrundlagen, Berechnung, Gestaltung und Versuch. By W. Kamm. Julius Springer, Berlin, 1936. Cloth, 8 × 11 in., 237 pp., illus., diagrams, charts, tables, 29.70 rm. This volume provides a comprehensive discussion of automobile design and construction, based upon the courses given by Professor Kamm at the Stuttgart Technical High School. The text is concise, but all elements of the automobile are discussed and illustrated by a wealth of drawings and photographs. A useful bibliography is included.

MACHINERY, EMPLOYMENT, AND PURCHASING POWER, published by National Industrial Conference Board, New York, 1936. Cloth, 6 × 9 in., 103 pp., diagrams, charts, tables, $2. This volume presents the essential available facts regarding the relation of machinery to the unemployment, employment, production, and purchasing power of the American working population. It combats the idea that private enterprise can not hope again to employ the working population and that the government must provide employment.

ÖESTERREICHISCHES PETROLEUM - INSTITUT (ÖPI-Veröffentlichung Nr. 3). Die Bestimmung des Aromatengehaltes in marktüblichen Benzinen. Edited by F. Lang. Verlag für Fachliteratur, Vienna, 1935. Paper, 6 × 8 in., 33 pp., diagrams, tables. As the presence of some aromatic hydrocarbons in gasoline is of importance from a hygienic point of view, the Austrian Petroleum Institute has surveyed critically the methods for determining the amounts present. The methods of analysis which seem most satisfactory are described.

ÖSTERREICHISCHES PETROLEUM - INSTITUT (ÖPI-Veröffentlichung Nr. 1). Alkohol - Gemischkraftstoffe. Verlag für Fachliteratur Ges. M.B.H., Vienna, 1934. Paper, 6 × 8 in., 31 pp. A brief, general, critical review of the literature on alcohol and gasoline blends for automobile fuels, prepared by the Austrian Petroleum Institute. A bibliography is included.

DIE SCHREIBMASCHINE UND IHRE ENTWICKLUNGSGESCHICHTE. By E. Martin. Fifth edition. Part 1. Verlag Johannes Meyer, Pappenheim, 1934. Cloth, 5 × 6 in., 816 pp., illus., diagrams, 14.65 rm. An immense amount of information upon the typewriter is presented in this little volume, which traces its development from the early eighteenth century to the present. Some six hundred models are described in considerable detail and, in most cases, illustrated. The book is a mine of data upon its subject.

TRAINS, TRACKS, AND TRAVEL. By T. W. Van Metre. Simmons-Boardman Publishing Company, New York, 1936. Cloth, 6 × 10 in., 296 pp., illus., $3. Professor Van Matre has again revised his popular description of our railroads and issued a fourth edition, brought up to date in text and illustrations.

THE PRESIDENT'S PAGE

Choosing Your Officers

AT THIS time of the year when the Nominating Committee of The American Society of Mechanical Engineers is facing the task of naming the officers and members of Council for whom you will have an opportunity to vote next fall, it is well to remind ourselves what safeguards are set up in our procedure to assure us of wise and truly representative choices by the Committee.

For convenience of Society organization the nation is divided into seven geographical districts or groups. Group 1 includes the New England states—and Group 7 the Pacific and Mountain states. Once a year every local section of the Society within each of these seven districts sends delegates to one of the seven group conferences held in the fall. At these conferences each group elects a member of the Nominating Committee and an alternate. Thus each of the seven groups has the opportunity of being represented by its ablest men.

The seven members and seven alternates organize themselves as the Nominating Committee during the Annual Meeting, and from that time until the Semi-Annual Meeting, by personal interviews and correspondence, individually and as a committee, they make the widest possible survey of the names suggested to them of the men available for these high elective positions and of the needs of the Society. At the Semi-Annual Meeting they hold open sessions at which any member may appear in support of a candidate. Finally, in private session, this Committee comes to a decision and announces the nominations for the offices of president, treasurer, vice-presidents, and members of Council to be voted on by the members.

In this procedure two important principles are observed: First that every member shall have an opportunity personally or by correspondence to communicate his views to the Committee, and second, that, with equal representation through elected local-section delegates, no single district may control the nominations.

REPRESENTATION ON A.S.M.E. COUNCIL BY GROUPS, 1922–1936

Group no.		1936 Membership	Members of 1936 Council	Elected to Council 1922–1935	Presidents 1922–1935
1	New England	1364	3	12	1
2	Metropolitan	3334	2	19	4
3	Middle Atlantic	2040	4	14	2
4	South East	770	2	10	0
5	Great Lakes	2037	4	15	1
6	Mid-West	1497	5	22	5
7	Pacific Coast	926	2	11	1

That the seven geographical groups have been adequately represented on the Council in recent years is proved by the accompanying table, which gives the number of members in each group, the number of persons from each group on the 1936 Council, and the number of presidents of the Society and members of Council elected from each group from 1922 to 1935. Here is a striking example of a Society whose members elect their own officers, including the President, that have been nominated by a committee representing every section of the country and accessible to every member. As nearly as possible the ideal of a society with officers truly representative of its members, has been approached. The responsibility and privilege of choosing your officers is yours.

M. L. Batt.

WHAT'S GOING ON

Including News of A.S.M.E. Affairs

This Month's Authors

CLYDE S. McDOWELL, captain, U. S. Navy, to whom we are indebted for the first description of the famous 200-inch telescope of the California Institute of Technology, is on leave of absence from the Navy for the purpose of acting as supervising engineer in charge of design and construction of this gigantic instrument. Captain McDowell was graduated from the U. S. Naval Academy in 1904, following which he served 13 years at sea, during the last two of which he was staff commander of the U. S. submarine forces. Since then he has been, successively, member of the special antisubmarine board and commander of the Experimental Station in New London, Conn.; staff commander in chief of the U. S. naval forces in European waters; naval inspector of machinery at the General Electric Co.; construction superintendent of the New York Navy Yard; staff commander of the base force, U. S. Fleet; engineer officer, Mare Island Navy Yard; inspector of navy material, San Francisco; manager of the Navy Yard at Pearl Harbor; and naval inspector of machinery at the Westinghouse Co. and the New York Shipbuilding Co. He received the honorary degree of Doctor of Science from the University of Wisconsin in 1921, served as vice-president of the A.I.E.E. in 1921–1922, and has received the Navy Cross for War Service.

ALBERT W. BREELAND, author of the paper "Training Petroleum Workers," is supervisor of safety of the Lone Star Gas Company, Dallas, Texas. He received his education in Mississippi. After a year's teaching he served with the American Expeditionary Forces. From 1920 to 1922 he was in the employ of the Missouri-Kansas-Texas Railroad, following which he became associated with the Lone Star Gas Company. He is now a member of the Federal Committee on Apprentice Training, the A.G.A. Accident Prevention Committee, the A.P.I. Topical Committee on Education, and is vice-chairman of the petroleum section of the National Safety Council.

L. K. SILLCOX, member, A S.M.E., and vice-president, New York Air Brake Company, has had abundant experience in railroad and industrial work since 1903, having served, in the order named, the New York Central Lines; the McSherry Mfg. Co., Middletown, Ohio; the Canadian Car & Foundry Co., Montreal; the Northern Railway Systems, Toronto; and the Illinois Central Railroad. From 1918 to 1927 he was superintendent of motive power for the C.M. & St.P. Ry. at Chicago, and since 1927 has been vice-president of the New York Air Brake Company, Watertown, N. Y. With this broad background of practical industrial and railroad experience, and his close association with the development of braking equipment for many of the newer light-weight, high-speed trains, Mr. Sillcox is patricularly competent to discuss the problems of the streamlining of railway trains. His services have been profitably utilized by the many engineering and railroad societies and clubs of which he is an active member, particularly by the A.S.M.E. which he has served as chairman of the Standardization Committee and the Railroad Division. As chairman of the Mechanical Advisory Committee for the Federal Coordinator of Railroads, Mr. Sillcox, through his committee, has recently submitted an extensive report which is still in the Coordinator's hands.

C. L. ORR, member, A.S.M.E., and power-plant manager of the Texas Gulf Sulphur Company, is the author of "Power and Heat Problems in the Sulphur-Mining Industry." Mr. Orr was educated at the University of Texas and Stevens Institute of Technology. During the early part of the World War he served as an instructor in the School of Military Aeronautics at Austin, Texas, and later became an officer in the U. S. Navy. Since 1919 he has been associated with the Texas Gulf Sulphur Company as efficiency engineer, chief operating engineer, and from 1926 to date, as power-plant manager.

"Flame-Cutting Steel Plate," is based on a series of studies made by J. H. ZIMMERMAN, member, A.S.M.E., and assistant professor of mechanical engineering at Massachusetts Institute of Technology, and specialist in the materials of engineering. Professor Zimmerman was graduated from M.I.T. in 1923 with the degree of B.S., and received his M.S. in 1926. Readers of MECHANICAL ENGINEERING will recall a previous contribution by Professor Zimmerman in which he reported the earlier phases of his researches in the flame-cutting of structural steel, published in the July, 1935, issue.

WILSON P. GREEN, junior member, A.S.M.E., and now engaged in experimental work with the C. F. Burgess Laboratories, Bokeelia, Fla., developed the material on which his paper on "Air Conditioning by the Sun" is based at the University of Florida, where he received the degrees of A.B. and B.S. Upon graduation he taught mathematics and industrial arts in high school for two years and then returned to the University as graduate assistant in the mechanical engineering department where he completed work leading to a master's degree in engineering. He has specialized in air conditioning and refrigeration.

C. W. FOULK, professor of analytical chemistry at The Ohio State University, has had a long experience in the study of industrial and boiler waters on which to base his paper "Suspended Solids in the Foaming and Priming of Boiler Water." He was graduated in 1894 with the degree of A.B., from the university on whose faculty he is at present serving and studied two years at the Chemical Institute of Leipzig, Germany. For several years he was engaged in commercial analytical work, after which he became a member of the Ohio State faculty. He has written extensively on the foaming and priming of boiler waters.

This month's review of economic literature, "The World Depression," from the Department of Economics and Social Science of the Massachusetts Institute of Technology, under the sponsorship of the A.S.M.E. Management Division, is by E. R. LIVERNASH, a graduate of the University of Colorado in 1932, who received a master of arts degree in economics at Tufts College in 1934. At present he is an assistant in economics at M.I.T. and is studying for a doctor's degree at Harvard.

Actions of A.S.M.E. Executive Committee

AT THE March 14 meeting of the Executive Committee of The American Society of Mechanical Engineers the following actions of general interest were taken:

WORLD POWER CONFERENCE

The committee voted to authorize the appointment of a representative to cooperate in the preparation and arrangements for "Study Tours" in connection with the Third World Power Conference in September, 1936. A. D. Blake has since been appointed to this position.

A.S.M.E. STAFF APPOINTMENT

It was reported that J. B. Patterson has taken over responsibility for making contact with local sections and student branches in the Midwest area, with headquarters at 1617 Engineering Building, 205 W. Wacker Drive, Chicago, Ill.

POLICY ON DELINQUENT MEMBERS

A codification of policies for handling delinquent members was approved, as follows:

Suspended Members. Suspended members may apply for return to active status prior to Sept. 30, 1936, by payment of dues prorated up to Sept. 30, 1936. Such reinstatement is automatic and requires no committee approval.

Upon reinstatement, a suspended member shall retain his original date of election. The number of years suspended, however, shall not be included in the number of years necessary for dues exemption. (Executive Committee of Council, April 21, 1934, and Council action Dec. 2, 1934.)

Resigned Members. Resigned members may apply for reinstatement up to Sept. 30, 1936, by written request to the Board of Review and by payment of the dues prorated to the end of the year in which they apply; no initiation fee to be required. After Sept. 30, 1936, the regular policy of reinstating resigned members should be resumed, namely, that the resigned member applying for reinstatement within one year of date of resignation is not required to pay a new initiation fee, those applying after one year to be classed as new members.

Members who resigned during the period from Oct. 1, 1932, to Sept. 30, 1936, upon reinstatement shall retain their original date of election. The number of years, however, that they did not pay dues to the Society shall be deducted from the number of years necessary for dues exemption eligibility. (Council action Dec. 2, 1934, Feb. 23, 1935, and Dec. 6, 1935. Letter ballot of Council Feb., 1936.)

Dropped Members. The present policy of reinstating dropped members by payment of new initiation fee plus one year of their dues arrears should be continued in effect except that no dues in arrears shall be required from those applying for reinstatement prior to Sept. 30, 1936. The Board of Review shall pass on all such requests except where individual qualifications, i.e., transfer to higher grade, are concerned, in which case the Committee on Admissions will be consulted. (Council Actions Dec. 2, 1934, and Dec. 6, 1935).

A dropped member reinstated under the above plan is recorded as elected in the year in which such reinstatement is effective.

A dropped member wishing to regain his original date of election must pay all dues arrears owing at the time of termination of his membership plus full dues for the intervening years.

A record of dues canceled shall be recorded in the member's account and his period of permanent dues exemption after 35 years' membership or after age of 70 following 30 years of membership, postponed by the number of years for which dues were canceled.

Future Resignations. The Board of Review shall consider all requests for resignations and recommend suitable action to Council. The Board shall classify all resignations and report to Council. (Council action Dec. 6, 1935.)

COMPTROLLER ADDED TO STAFF

It was voted to authorize the president to appoint a comptroller, responsible to the secretary. D. C. A. Bosworth was subsequently appointed and took up his duties as a member of the headquarter's staff April 6.

ROSTER OF STUDENT MEMBERS

The recommendation of the Committee on Publications that the roster of student members be published in the May issue of the *Student Branch Bulletin* was approved.

ONTARIO SECTION TRANSFERRED TO GROUP V

The Committee approved transfer of the Ontario Section from Group III to Group V.

NATIONAL DEFENSE COMMITTEE AUTHORIZED

Approval was voted of the appointment of a Committee on National Defense superseding the present National Defense Division, reporting directly to the Council of the Society, with the following functions: Cooperate with the government of the United States and other bodies in those activities pertaining to the defense of the nation in which the abilities and loyalties of engineers are needed. The committee is to consist of seven members, one appointed by the U. S. War Department, one by the U. S. Navy Department, and five members of the Society appointed by its President. The terms for Society members shall be overlapping for five years, one appointment being made each year.

PINS FOR ASSOCIATES

It was voted not to require present associates of the Society to turn in their blue pins for the new green ones.

PEDESTAL FOR WATT BUST

As an expression of appreciation on the part of the New York Chapter of the Railway and Locomotive Historical Society for the use of the A.S.M.E. rooms for its monthly meetings, it was reported that that society wished to contribute a pedestal for the bust of James Watt, presented to the A.S.M.E. by the American Society of Civil Engineers. (See MECHANICAL ENGINEERING, February, 1936.) The Committee voted its sincere appreciation of this gift.

MEETING OF APRIL 21

Further actions taken at the meeting of April 21 are as follows:

PROGRAM FOR 1936

A program of activities was accepted, and discussion of some of its projects occupied much of the Committee's time. An outline of the program follows:

I Executive Committee
- 1 Relief and employment
- 2 Membership development
- 3 Society activities.

II Officers and Council

Visits and other services to interpret American Engineering Council; encourage cooperation locally between all organized groups of engineers; encourage strengthening of the Society by the selection of able leaders as section officers; encourage building up of membership by bringing in outstanding engineers as members.

III Committee on Policies and Budget
- 1 Recommend organization changes to make management and operation more responsive
- 2 Define aims, objectives, and ideals of the Society and enunciate broad policies for achieving them.

IV Advisory Board on Technology
- 1 Divisions reorganization
- 2 Development of plan for Transactions in accord with needs of members and divisions
- 3 Scrutinize continually publication program
- 4 Establish uniform policy for handling presentation and publication of papers and reports.

V Sections
- 1 Selection of able leaders as section officers
- 2 Cooperation locally with all engineering groups and engineering interests
- 3 Establish organization to plan and administer junior interests.

VI Constitution and By-Laws
- 1 Complete study of revisions.

VII Committee on Finance
- 1 Complete long-range financial program
- 2 Recommend personnel for Committee on Funds and Endowments.

RELIEF AND EMPLOYMENT

The secretary reported that the National Employment Committee had initiated a study of the details of operation of the New York office, and was asked to advise the National Employment Committee that the Society was engaged in a critical examination of its participation in the employment function.

ENGINEERING HISTORY

It was voted to approve a plan for a Joint Committee on Engineering History, subject to the approval of other participating bodies.

DUES FOR "SIX-YEAR" JUNIORS

Approval was voted of the recommendation of the Board of Review that, upon submission

HOW TO BE REINSTATED IN A.S.M.E. MEMBERSHIP

SUSPENDED members may return to active status without filing an application and without loss of seniority by payment of dues prorated from date of reinstatement to September 30, 1936.

Resigned members may return to active membership by written request to the Board of Review without additional initiation fee by payment of dues prorated from date of reinstatement to September 30, 1936.

Dropped members may return to active membership by payment of the usual initiation fee and dues prorated from date of reinstatement to September 30, 1936.

of a satisfactory statement, the $10 rate of membership dues be continued for one year to those juniors elected in 1929 who are financially unable to meet the automatic increase in dues in 1935.

RESOLUTION ON DEATH OF F. R. LOW

The Boiler Code Committee transmitted the following resolutions which it has passed upon the death of Dr. Fred R. Low:

WHEREAS, Through the death on Jan. 22, 1936, of Dr. Frederick R. Low, who has been chairman of our committee for over ten years, we have lost a beloved and honored leader; and

WHEREAS, He has rendered invaluable service in formulating the rules for safety which have been issued by our committee and has taken a leading part in establishing its policies, and

WHEREAS, We esteem his memory as a faithful coworker whose humanity and kindness made every one his friend; therefore, be it

Resolved, That these resolutions be spread in full on the records of the committee, and copies be sent to his bereaved family and to the Council of The American Society of Mechanical Engineers.

STANDARDS APPROVED

Record was made of approval by the Council for adoption as standard practice of the American Standards for chucks and chuck jaws and for lathe-spindle noses.

APPOINTMENTS

The following appointments (made since the issuance of personnel lists, Society Records—Part I, Transactions, February, 1936) were recorded at the meeting of March 14: To the Committee on Policies and Budget, W. D. Ennis (treasurer, ex-officio), A. L. Penniman, Jr., W. L. Edel, and R. S. Brescka; Advisory Board on Professional Status, V. M. Palmer (registration); Sectional Committee of Code for Protecting of Heads, Eyes, and Respiratory Organs of Industrial Workers, T. A. Walsh, Jr.; Mechanical Standards Committee, A.S.A., Alfred Iddles, Walter Samans, alternate; Joint Research Committee on Effect of Temperature on Properties of Metals, Francis B. Foley and R. H. Aborn; Erik Oberg Testimonial, John H. Lawrence, chairman, Roy V. Wright, R. M. Gates, W. A. Shoudy, and K. L. Martin; President's representatives at Student Branch Conferences, Harry R. Westcott, Alfred Iddles, R. L. Sackett, E. W. O'Brien, Alex D. Bailey, J. W. Haney, E. O. Eastwood, and W. Lyle Dudley; Annual Meeting, Jos. A. Holmes Safety Association, J. F. Barkley; Annual Meeting American Academy of Political and Social Science, W. H. Fulweiler, K. M. Irwin, and H. Birchard Taylor; Fiftieth Anniversary, Illinois Society of Engineers, Alex D. Bailey.

Appointments reported at the April 21 meeting were as follows: Finance Committee, K. W. Jappe; Education and Training for the Industries, John H. Ploehn; Power Test Codes, Milton C. Stuart; Boiler Code, Samuel K. Varnes; Advisory Board on Technology, G. F. Bateman (publications), Ely C. Hutchinson (meetings and program); Power Test Codes Committee on Dust Separating Apparatus, Ollison Craig; A.S.T.M. Committee on Water for Industrial Uses, George D. Bearce; World Power Conference, American National Committee, Coordinating Committee, A. D. Blake, W. E. Caldwell (alternate); Midwest Power Engineering Conference, W. L. Abbott; Lafayette College "Seventy Years of Engineering Education," B. H. Jennings; 75th Anniversary Svenska Teknologforeringen, Stockholm, Sweden, Manne T. Lindhagen.

Oil and Gas Power Meeting, Ann Arbor, June 24–27

THE ninth national Oil and Gas Power Meeting will be held at the University of Michigan, Ann Arbor, Mich., June 24–27, under the auspices of the University, the Oil and Gas Power Division of The American Society of Mechanical Engineers, and the Detroit Section of the Society. The meeting will begin on Wednesday June 24 with registration at the East Engineering Building and will consist of six technical sessions and two inspection trips.

There will be the same delightful atmosphere that has been a feature of the meetings of this Division in previous years. Special arrangements for the lodging and entertainment of A.S.M.E. members in attendance at the meeting have been made on the beautiful campus of the University. An eighteen-hole golf course will be available and opportunities for hiking along the Huron River Valley may be enjoyed by all. On Friday afternoon a choice of inspection trips is offered. Visits may be made either to Henry Ford's Greenfield Village or to the Ford Motor Car Company plant.

Technical sessions and registration are being conducted in the East Engineering Building. An exhibit of Diesel accessories will also be held in the East Engineering Building during the period of the meeting. As in the past the exhibit will prove to be a special attraction. A complete program will be sent about June 1 to those registered in the A.S.M.E. Oil and Gas Power Division and to other members of the Society who may request it. A detailed program follows:

WEDNESDAY, JUNE 24

9:00 a.m.

Registration, East Engineering Building

2:00 p.m. General

Diesel-Engineering Training, by F. G. Hechler
Effect of Legislation on Diesel Development, by L. H. Morrison
Research Activities at University of Michigan, including Spectroscopic Control in Foundry, Shock-Absorber Lubricants and Behavior of Metals at High Temperature

Evening Dance

THURSDAY, JUNE 25

9:30 a.m. Design

Bearing Design, by Harte Cooke
Engine Governing and Speed Regulation, by Frank Hodgkinson
Discussion Diesel-Operating Characteristics with Various Loads

2:30 p.m. Operating

Performance of Lubricants Based on Service Conditions, by C. M. Larson
Diesel Operating and Maintenance Problems, by L. M. Goldsmith
Vibration Control of Internal-Combustion Installations, by S. Rosenzweig

Evening High-Speed Engines

Fuel-Injection Spark-Ignition Oil Engine, by N. Fodor
Discussion of High-Speed Diesel and Gas-Engine Development

FRIDAY, JUNE 26

9:30 a.m. Research

Diesel-Fuel Research, by M. J. Reed and A. E. Becker
Diesel Power Cost Report, by H. C. Major

2:30 p.m. Recreation

Trip to Henry Ford's Village or Ford Motor Co. plant

Evening Banquet

SATURDAY, JUNE 27

9:30 a.m. Recent Developments and Applications

Discussion of Gas-Engine Developments
Discussion of Operation of Diesel Trucks and Busses
Discussion of Diesel-Engine Applications to Railroad Locomotives

Applied Mechanics Meeting, Pittsburgh, June 11-13

THE Fourth National Applied Mechanics Meeting will be held at the Carnegie Institute of Technology, June 11–13, under the auspices of the Institute, the Applied Mechanics Division of The American Society of Mechanical Engineers, and the Pittsburgh Section of the Society.

The four technical sessions scheduled for the meeting will be devoted to (1) thin-walled structures, (2) plastic flow and creep, (3) vibration, and (4) general technical subjects.

Arrangements are being made for a visit to the research laboratories of the Westinghouse Electric and Manufacturing Company, the Aluminum Company of America, and the Gulf Company. All technical sessions will be held at the Institute and inspection trips will leave from there.

The annual dinner will be held on Saturday evening. Two hotels, adjacent to the Institute, the Webster Hall Hotel and the Hotel Schenley, will afford accommodations for those attending the meeting. Hotels in the business section of Pittsburgh are also available.

The local committee arranging the meeting consists of R. E. Peterson, chairman; M.

Frocht, vice-chairman; J. A. Dent, A. V. Karpov, A. Nádai, R. J. S. Pigott, R. L. Templin, K. F. Treschow, and M. Stone.

A complete and revised program will be mailed about May 25 to every one registered in the A.S.M.E. Applied Mechanics Division, and to other members of the Society who request a copy.

As complete a program as is possible to present at the time of going to press follows:

THURSDAY, JUNE 11

Morning: Thin-Walled Structure Session. Papers on thermal stresses, buckling of rectangular plates, and bending of clamped rectangular plates.

Afternoon: Visit to Westinghouse Research Laboratories.

Evening: Committee meetings.

FRIDAY, JUNE 12

Morning: Plastic Flow and Creep Session. Papers on overstressing of plates to improve stress distribution at holes, and creep under combined stress.

Afternoon: Visit to Aluminum Company Research Laboratory and the Gulf Research Laboratory.

Evening: Dinner or Meeting.

SATURDAY, JUNE 13

Morning: Vibration Session. Papers on nonlinear vibrations, the vibrations of turbine foundations, self-induced vibrations.

Afternoon: General session. Papers on a method of determining the mean surface temperature of tubes, the efficiency equation for gears, an analysis of film-lubricated bearings of finite length, and an approximate method for the determination of principal stresses.

Evening: Annual Dinner.

PIRAMIDE DE "TEOPANZOLCO," CUERNAVACA, MORELOS, MEXICO

Late News of A.S.M.E Dallas Meeting, June 15–20

FINAL arrangements are rapidly taking shape for the Semi-Annual Meeting of The American Society of Mechanical Engineers at Dallas, Texas, June 15–20. A local committee, of which E. W. Burbank is chairman, is making every effort to perfect the details of entertainment and program that will insure smoothly running technical sessions and enjoyable social events.

ADDITIONS TO TECHNICAL PROGRAM

Since its publication, in the May issue of MECHANICAL ENGINEERING, pages 332 to 336, some changes in the program of technical sessions have been announced. Of most importance is the addition of a session on air-conditioning that is now scheduled for Tuesday morning, June 18. Two papers for this session will be "Air Conditioning in Humble Oil Company Building," by E. W. Becker, and "Air Conditioning the Robinson Gold Mine," by O. W. Bynum.

A technical session on Diesel engines has been added to the program for Thursday afternoon with a paper by N. Fodor on "Fuel-Injection Spark-Ignition Oil Engines," and another by T. B. Rendel on "Diesel Fuels."

In its present form the technical program provides 19 technical sessions at which upward of 50 papers will be presented and discussed. At the time of printing the program in the May issue the names of some of the authors of papers listed were not available. Some of these have since been announced. The paper entitled "Texas Industrial Development," will be presented by J. B. Thomas. B. F. Hunter is the author of the paper, "Railroad Lubricants," and M. C. Van Gundy of that on "Production of Locomotive Fuel Oil." Other authors whose names have recently been announced, and the titles of the papers they will present, are as follows: Stanley Gill, "New Methods of Oil-Fuel Production;" E. L. McDonald, "Heat-Balance Vs. Water-Weighed Boiler Tests;" H. V. Beck, "Fluid-Meters Research;" H. W. Harms, "Air Corps Training;" D. W. Smith, "Steam-Drilling Equipment;" J. P. Klep, "Wider Line Coring in Hard Formations;" R. D. Robey, Jr., "Semi-Diesel Mechanically Operated Rotary Rigs;" and J. M. Cooper, "Small High-Speed Gas Engines for Pumping."

NOMINATING COMMITTEE MEETING

The Nominating Committee of the Society will be in session at the Hotel Adolphus on Tuesday and Wednesday during the meeting. Members of the Society who wish to appear before the Committee on behalf of proposed candidates for offices will find the times and locations of the open hearings of the Committee posted at the hotel.

THE VALENCIANA CHURCH, GUANAJUATO, GTO., MEXICO

Tour to Mexico

THE post-convention tour to Mexico City, as announced in the May issue, will leave Dallas on June 20, and arrive in Mexico City, June 23, with a stopover of one day at San, Antonio, Texas. The cost of this ten-day all-expense tour from Dallas to Mexico City and return, on the basis of a lower berth, is $130 per person.

A special circular describing the tour is being prepared. For further information write to the A.S.M.E. headquarters, 29 West 39th Street, New York, N. Y.

Special Train to Dallas

AS announced last month, arrangements have been made for a special train on the Missouri-Kansas-Texas Railroad for the convenience of members of the A.S.M.E. and guests en route to the Dallas meeting. The A.S.M.E. Special leaves St. Louis, Mo., at 5:30 p.m. June 15 and arrives in Dallas at 9:30 the following morning. Connections with this train for those going from such points as New York and other eastern cities, Milwaukee and Chicago, Pittsburgh, and Detroit have been arranged so that special A.S.M.E. cars will arrive in time for members to board the special train at St. Louis. Those coming from Minneapolis, St. Paul, Des Moines, and Omaha will make connections at Kansas City, where special cars will leave for Dallas at 3 p.m., June 15, arriving the following morning at 6:15 a.m.

Complete schedules and detailed arrangements may be secured by writing to A.S.M.E. headquarters, 29 West 39th Street, New York,

N. Y. Railroad rates cannot be quoted at this time with assurance that they will be in effect in June. However, it is confidently expected that some reduction from regular rates will be available.

A.E.C. News From Washington

ALL of the Washington palliatives have failed so far to make any real dent in the number of unemployed. Estimates of unemployed vary from eight million to fourteen million, but the estimators, whether they are on the high side or the low side, have not changed their estimates materially in three years. Statistics on unemployment, of course, are notoriously inadequate, but the broad fact remains that the total number of unemployed today is approximately the same as it was three years ago. Ouside of this simple fact, however, the employment situation is full of paradoxes. It is known that there is a definite shortage of skilled help in the building trades in some localities and if we should have any large advance in the machinery industries, there would be a dearth of skilled mechanics, toolmakers, and other trained craftsmen.

The government policy continues to be a "work-relief" policy under WPA. Many engineers are employed in the government—in PWA and WPA and in some 70 other departments or divisions, but indications are that during the months to come an increasing number of men will be dropped from the government payrolls and among these will be several thousand engineers. It should be fair to prophesy, therefore, that the employment of engineers by the government has reached its peak and that there will be a gradual recession in the number of those so employed. Meanwhile, private employment of engineers is slowly increasing. One of the indexes of this increase is seen in the return of engineers to membership in local and national engineering organizations.

Engineers, however, have more than a personal relation to questions involved in our national reemployment policies. With the return of more normal conditions, the engineer is an employment creator. Reemployment of men in large numbers depends fundamentally on the reemployment of capital for the production of new materials, new machines, and new buildings. The engineer-led and -managed capital-goods and construction industries still lag behind the so-called consumption-goods industries. The fundamental reasons for this lie outside the field of technology and in the realm of finance and economics. The public must eventually become conscious of the fact that the reemployment of capital underlies the reemployment of men, and until our national policies with regard to taxation, federal control of industry practices, and the determination of broad labor policies are settled, the normal processes of reemployment of capital will not take place. Meanwhile, there is an awakened interest in this whole problem outside of government. At the meeting of the U. S. Chamber of Commerce several phases of the problem of reemployment were presented and a real stimulus was given to the thought that new products, new services, and new inventions, all engineer-created products, presented one of the most hopeful opportunities for the reemployment of capital and consequently the reemployment of men.

Under the WPA, $12,000,000 was allotted last December for a study under a National Research Program of "Reemployment Opportunities and the Changes in the Techniques of Production." This study is just getting under way under the direction of Dr. David Weintraub with headquarters at Philadelphia. Some of the factors that are proposed include the measurement of the volume of technological unemployment, changes in productivity in selected groups of industries, and the historical analysis of the development of techniques in relation to the development and standards of living.

There is need for engineering statesmanship in a consideration of this total problem. There are at present no basic statistical data upon which decisions can be made as to the influence of technology on employment. We are already starting to tax payrolls for social security without knowing yet how many people are employees and how many are employers. It seems evident that if we tax payrolls to provide money for pensions and unemployment insurance, we will reduce payrolls. When this happens, probably someone will decide to tax machine output and we will enter a vicious circle of increased production costs, increased cost to the consumer, and a further reduction in the number of employed. The American Engineering Council's Committee on the Relation of Consumption, Production, and Distribution has expressed the belief that an "economy of abundance must replace an economy of scarcity," to use the latest phrase, if we are to find the answer to a rising standard of living in the United States. Several areas of this whole question can profitably be studied from an engineering viewpoint and it is anticipated that the Committee on Engineering Economics of the American Engineering Council will give consideration to some of these questions.

GOVERNMENT AGENCIES ACTIVITIES

Almost all administrative branches of the government are busy with the execution of programs wholly or partially financed by previous appropriations, but the planning division of both regular and emergency agencies are "marking time" until they know more about the purposes and size of appropriations which may come with current legislation. Current appropriations for social programs alone may total close to two and one half billion, with 1500 million for relief, 370 million for CCC, 40 million for TVA, and 200 million for Social Security, an interesting estimate to be added to a federal deficit accruing at a daily rate of $11,250,000.

PUBLIC WORKS ADMINISTRATION

According to a recent PWA survey, 83 per cent of elections, held in all but three of 3073 counties in 48 states, resulted in popular authorization of bonds to cover 55 per cent of the funds to finance projects for local communities. The other 45 per cent is being provided by grants from the Public Works Administration. All of that wide-spread popularity only involved $213,621,592 in contributions to match $150,390,286 in grants, making a total of $364,011,878. In that connection, it is interesting to note that the total is small in comparison with the normal volume. Secretary Ickes reports that over 90 per cent of the projects involved have advertised for bids and that almost 80 per cent of them are under construction or complete. He says that the overall average cost to the government of giving one man work for one year on the first thousand projects was $741.60. That figure, however, is based upon the old PWA Policy of 30 per cent grant instead of the present 45 per cent and does not include any portion of the major cost of projects borne by local communities. There is little to add to press reports regarding the campaign for funds to continue the program of the Public Works Administration, except the observation that unofficial estimates indicate a several hundred million dollar reserve from unexpended appropriations and the possibility of a substantial revolving fund from the sale of bonds, including the profits on them, received in satisfaction of previous loans.

RURAL ELECTRIFICATION ADMINISTRATION

Although the bill for the ten-year program is still in conference, it is expected to pass this session. In the meantime, invitations to bid on the construction of rural electrification projects have been issued by electric service cooperatives and associated private utilities in a number of states; and 20 of the 27 projects on which loan contracts have been executed are, or soon will be, in the construction stage. It also seems that the Rural Electrification Administration is trying to keep the usual channels of trade open for wiring and appliance business in the rural areas. In that connection Morris L. Cooke predicts "a new era of expansion for the electric trade" and suggests that the "trade will be well advised to give less concern to fears of what the cooperatives may do than to accepting the challenge and going out after new business."

EMERGENCY CONSERVATION CORPS

The Civilian Conservation Corps is credited with a surprisingly large amount of work in an official report recently prepared by Director Robert Fechner for the White House. It states that 1,600,000 men and boys have found an average of eight months' employment in that service. They have worked under the direction of the Departments of War, Interior, and Agriculture in every state in the Union on 17,500,000 acres and have built or repaired 69,000 miles of service roads and trails; 42,000 miles of telephone lines for fire-protection and park service; 47,000 miles of fire breaks through forested areas; 2500 lookout houses; 1,900,000 soil-erosion check dams in gullies; 25,000 vehicle bridges, and planted 558,000,000 forest trees over denuded areas. All of this is now reported to have an actual value of more than $600,000,000.

These figures do not include any attempt to estimate the social and economic value of employment, training, and discipline for a large percentage of the youth of this country or the benefit derived from the monthly remittances made by these boys to their families.

WORKS PROGRESS ADMINISTRATION

With the President's support, Harry L. Hopkins and his organization now seem almost certain to be entrusted with another billion and a half relief appropriation for 1936–1937. It is now scheduled to be included in the deficiency appropriations. No "ear marking" beyond Mr. Hopkins' estimate of over $500,000,000 for roads and the more permanent type of construction is in evidence, but he has promised "a more useful" program. Added to the estimated balance from 1935–1936, after all corrections, such an appropriation may total approximately $2,500,000,000 for relief and work relief at the discretion of the Works Progress Administration.

COUNCIL'S COMMITTEE ACTIVITIES

Organization of all divisions of A.E.C.'s committees is complete. Every engineer asked to serve has accepted the responsibility with an eagerness to advance the public's appreciation of the value of engineering judgment, training, and experience. Many of the committees have already gone into action and most engineers engaged in the work will be included in programs of committee activities which will soon be ready for distribution.

The report of the committee on production and distribution is in the final revision stage and will soon be submitted to member organizations. The committees on public works, and conservation and utilization of natural resources are completing the first reports of their respective programs. Favorable action has already been taken to support a new court of patent appeals and the patents committee is now engaged in the preparation of recommendations for the improvement of patent procedure.

LEGISLATION AND GOVERNMENT REGULATIONS

Current legislative procedure in the Congress is subject to so much and such rapid change that it is usually inadvisable to attempt definite support of any one piece of legislation until it is favorably reported by the investigating committee for definite consideration. A new bill frequently supersedes the old one before sufficient time elapses to provide for the preparation of a considered opinion. It is our policy to follow all bills affecting engineers and engineering as well as those affording opportunities to act in the public welfare; and with our improved committee organization we hope to be able to present considered opinions to the proper authorities in time for them to be used in connection with the enactment of legislation of that nature.

New government regulations are seldom issued under present conditions but it is evident that many of them are in preparation and as soon as the new programs are approved many new rules, regulations, and procedure are likely to become effective. Advance information regarding most of it indicates improvement in the practices of the emergency agencies.

FLOOD-CONTROL LEGISLATION

Omnibus Flood Control Bill H.R.8455 is reported out of committee but it is said to have slim chance of passage. Senator Copeland's S.4315 declaring "floods constitute a menace to national welfare" and authorizing $5,000,000 for flood control surveys throughout the United States by the Engineers Corps of the Army, is in the hands of the Commerce Committee of the Senate. They have asked the Chief of Engineers for an opinion and propose to report it in time for consideration.

NATIONAL RESOURCES COMMITTEE

The Public Affairs Committee has made a study of legislation proposed for the creation of a permanent national planning board or the continuation of the National Resources Committee. They are divided in their opinion regarding current legislation, but most of them favor sound planning by a nonpolitical organization under otherwise favorable circumstances. There is no indication that legislation of this nature will pass this session of Congress, but plans are being made for the introduction of a modified and more constructive form of legislation for the same purpose in the Seventy-Fifth Congress. The conception of a National Planning Board as presented by the National Resources Committee is not understood by many people. In Congress it is still interpreted, primarily, as an agency of the Secretary of the Interior and a "brain trust" engaged in long-range social planning of no immediate practical purpose.

ANTILOBBY LEGISLATION

Although the House and Senate have each passed bills—H.R.11663 and S.2512—defining lobbyists and providing for their regulation, neither bill is acceptable to both houses and it seems likely that the disagreement will prevent either of them from being favorably reported out of conference for action during this session. These bills should not be confused with Senator Wagner's S.2944 "to prevent and make unlawful the practice of law before government departments, bureaus, commissions and their agencies by those other than duly licensed attorneys-at-law." The Senate Judiciary Committee has reported unfavorably on it and, therefore, it is dead for this session of Congress.

STREAM-POLLUTION LEGISLATION

Hearings on Lonergan S.3958 "to prevent pollution of navigable waters" and S.3959 "to amend the Act of 1899 controlling discharge of refuse in navigable waters and the Act of 1924 preventing oil pollution" before Senator Caraway's subcommittee are complete, but not reported out of committee. Copeland S.4342 "to create a Bureau of Stream Pollution in the Bureau of Public Health Service" and Barkley S.4349, S.4350 and S.4351 "to control or reduce the pollution of the navigable waters of the United States and granting Ohio Valley consent of Congress to an interstate compact for that purpose" have all been referred to Senate Commerce Committee which does not expect to act on them. In the House Mansfield, H.R.8992 has been superseded by Pfeifer H.R.11064 "to prevent pollution of rivers and harbors of the United States;" and Hollister Bills for the same purpose have been referred to Committee on Rivers and Harbors of the House which does not anticipate action. Relief and taxation constitute "must" legislation for remaining days of this session.

A.S.M.E. Meetings Scheduled for Fall of 1936

TWO meetings of national scope and importance will be held in the fall of 1936 by The American Society of Mechanical Engineers, one at Niagara Falls, September 16–19, and the other at Cleveland, October 22–23.

NIAGARA FALLS, SEPTEMBER 16–19

The meeting at Niagara Falls, September 16–19, is timed so that engineers from abroad who will be in this country to attend the World Power Conference, some of whom will be on a tour of American plants, may participate in it. Inasmuch as the program of the World Power Conference is given over to the economic and social, rather than the technical, aspects of power, the Niagara Falls meeting affords an opportunity for the discussion of engineering papers. For this reason, power and fuels have been strongly stressed in setting up the program, and the Society is able to do its part in providing an opportunity for visitors to attend and participate in one of its meetings. The Society benefits directly because some of the engineers from abroad have been invited to present papers at the meeting. W. E. Caldwell and A. D. Blake are arranging the power and fuels program at the Niagara Falls meeting.

While emphasis has been placed on power subjects, the meeting at Niagara will provide an opportunity for the discussion of many other topics. The Hydraulic Division has planned a session devoted to hydraulic power and research for which papers by Canadian engineers have been promised. A varied program of four technical sessions is being arranged by the Wood Industries Division. The Process Industries Division will sponsor two sessions, and the Railroad, Aeronautic, Materials Handling, Iron and Steel, and Management Divisions will be responsible for one session each. Thus there is promised sufficient variety and quantity of technical discussion to interest a large percentage of the Society's membership.

CLEVELAND, OCTOBER 22–23

A two-day national meeting, devoted to a Symposium on Welding Practice, will take place in Cleveland, Ohio, Oct. 22–23. The program for the symposium is being arranged by the Machine Shop Practice Division of the A.S.M.E. Cooperating with this division are the Iron and Steel, Petroleum, Process Industries, and Applied Mechanics Divisions of the A.S.M.E., and the American Welding Society.

C. W. Obert is planning the technical program and the Cleveland Section of the Society will have charge of all local arrangements. The purpose of the symposium is to provide the engineer and designer with a well-balanced

review of developments and data in welding practice. It will be held during the week of the Metal Congress and the Exposition of the American Society of Metals.

ANNUAL MEETING, NOVEMBER 30 TO DECEMBER 4

Plans for the 57th Annual Meeting of the A.S.M.E., to be held in New York, Nov. 30–Dec. 4, are already under way. An all-day Symposium on Corrosion-Resisting Metals in Design will be an important feature of the technical program. T. H. Wickenden has undertaken the arrangements for the symposium under the auspices of the A.S.M.E. Iron and Steel Division. It is confidently expected that significant papers of timely value will afford a well-balanced review of this important subject. Cooperating in the symposium are the Machine-Shop Practice, Process Industries, Textile, and Petroleum Divisions.

Unwin Memorial Appeal

FRIENDS, associates, and past students of the late Dr. W. C. Unwin, throughout the entire world, have taken steps to commemorate the valuable service which William Cawthorne Unwin, who was an honorary member of The American Society of Mechanical Engineers, rendered to engineering science through research and published writings and particularly the lead which he took in the evolution of the scientific training of engineers.

The movement originated in London with a group of Dr. Unwin's former students and has led to the formation of a committee on which are represented many engineering and scientific societies. The American Society of Civil Engineers and The American Society of Mechanical Engineers were invited to join in the project and so that the steps might be more effective in the United States these two groups have been brought together in one agency to handle contributions in the United States.

In general, the Committee proposes to raise the sum of about $10,000 to be spent in preparation of a suitable memorial to provide a permanent record of Dr. Unwin's life and to amplify the endowment for the Unwin Scholarship awarded annually to a third-year student at Central Technical College—Dr. Unwin's School—to assist the student for a fourth year. As a final item, it is expected that a suitable portrait, bust, or bronze plaque of Dr. Unwin will be presented to the Central Technical College.

The American Committee is attempting to contribute the sum of about $2000 to the general fund and is addressing a communication to those men who have had the privilege of acquaintance with Dr. Unwin and who may wish to be included. Any contribution, however small, will be welcome.

For convenience in transmitting funds Otis E. Hovey, Treasurer of the American Society of Civil Engineers, has been appointed Treasurer for America, and remittances should be made out to him addressed to him at 29 West 39th Street, New York, N. Y.

The honorary chairman of the American Committee is Ambrose Swasey, honorary member and past-president, A.S.M.E., and the secretary is C. E. Davies. Representatives of the A.S.M.E. on the Committee are J. A. Goff, J. A. Hall, and R. E. W. Harrison; and those of the Am. Soc.C.E. are Robert Ridgway, A. H. Talbot, and C. L. Warwick.

S.P.E.E. Votes on Engineering Degrees

EDUCATORS in the field of engineering and members of engineering societies have on several occasions concerned themselves with the lack of uniformity in engineering degrees and the consequent confusion arising from the various practices of engineering schools. The Society for the Promotion of Engineering Education has had three different committees and reports on the subject, and the Engineers' Council for Professional Development has recognized the problem in the deliberations of its Committee on Professional Recognition.

The latest reports of the S.P.E.E. committee on degrees in engineering, presented at the Ithaca meeting in 1934, contained provisions for unifying the names of, and requirements for, engineering degrees, including honorary degrees. The Committee on Professional Recognition of E.C.P.D. heartily concurred in this report, with one exception, and urged its adoption as a step in clarifying the indefiniteness of the present situation. The single exception was taken to the proposal to abandon completely the professional degree, and E.C.P.D. expressed the hope that this proposal would receive further consideration by S.P.E.E. before adoption.

Using civil engineering as an example typifying the lack of uniformity and confusion in all engineering degrees, S.P.E.E. found seven forms of the first, or bachelor's, degree.

In contrast to this diversity, the S.P.E.E. committee recommended the following plan for engineering degrees, again using civil engineers as an example:

Academic

Bachelor of Civil Engineering (B.C.E.)
Master of Civil Engineering (M.C.E.)
Doctor of Civil Engineering (D.C.E.)

Honorary

Master of Engineering (M.Eng.)
Doctor of Engineering (D.Eng.)

Professional

Civil Engineer (abandon as earned or honorary)

In order to get a concensus of opinion on this plan, S.P.E.E. submitted the recommendations to letter ballot. Total ballots numbered 813 out of a membership of 2325, representing 160 institutions, with 50 voters outside of faculties. More than 80 per cent of the ballots were cast in favor of the forms suggested for the degrees, with the exception of that for the professional degree "abandoned as earned or honorary" for which the affirmative ballots cast were 61 per cent of the total.

The significance of the ballot is outstanding, and the results more than ordinarily conclusive. With the exception of the vote favorable to abandonment of the professional degree (C.E.) the results are also in accord with the preference of the Committee on Professional Recognition of E.C.P.D.

The latter organization had proposed that the professional degree might be granted only to experienced engineers who had otherwise met the requirements for certification into the profession.

Dr. John Orr Honored

DR. JOHN ORR, member A.S.M.E., professor of engineering, Witwatersrand Technical Institute, received the honorary degree of Doctor of Laws on March 21, from the University of the Witwatersrand.

A.S.T.M. Annual Meeting, Atlantic City, June 29–July 3

THE 1936 annual meeting of the American Society for Testing Materials will be held in Atlantic City at Chalfonte-Haddon Hall June 29 to July 3, inclusive. Several outstanding groups of papers will be given, the most extensive of which is the Symposium on X-Ray Crystallography and Radiography being developed by A.S.T.M. Committee E-4 on Metallography through its Subcommittee VI on X-Ray Methods. The symposium on limitations of laboratory and service tests in evaluating rubber products, which is being sponsored by Committee D-11 on Rubber Products is expected to be of widespread interest.

Several papers on various phases of spectrographic analysis are on the program and one session will be devoted entirely to the subject of water—this latter being sponsored by the Joint Research Committee on Boiler Feedwater Studies and A.S.T.M. Committee D-19 on Water for Industrial Uses. Other technical contributions will cover nonferrous metals, wire, soils, corrosion, fatigue and effect of temperature on metals, and cement and concrete, separate sessions being devoted to each of these subjects.

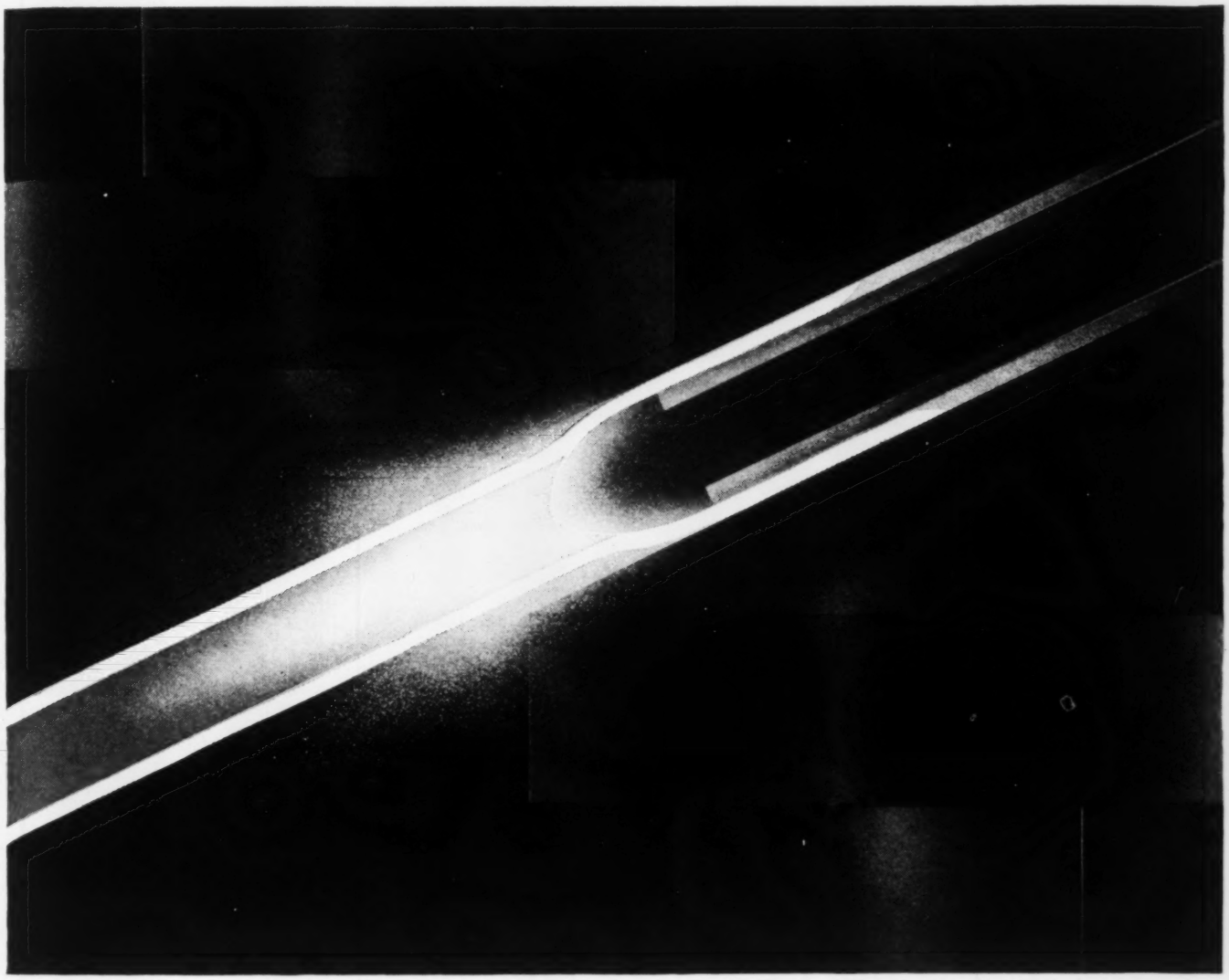
Safety and Hygiene Sections Organized by A.F.A.

WITH a view to making more effective the work the American Foundrymen's Association has carried on for a number of years, on plant safety, good housekeeping, and protection of foundry workers, a Safety and Hygiene section has been organized to accomplish the following purposes:

To determine further the extent of hazards to safety and health in the foundry industry; to study causes of hazards and methods of prevention, and to provide further protection to workers against exposure.

Cooperation with other centralized agencies

(*Continued on page 406*)



MOLY makes it cost less to pay more

It is often cheaper in the long run to pay more for your raw materials or your production machines. The savings from fewer breakdowns, better finished parts, and higher production speeds, often far outweigh the higher first cost.

"Moly" irons and steels have proved this point time and time again. In one case, .35% Molybdenum added to a cast-iron reeler plug increased production to 200 tubes per plug as against 80 to 90 formerly.

The plugs cost more — yes. But the difference was more than made up by their increased efficiency.

Moly steels and irons are usually less expensive than other alloyed steels and irons intended for like uses. And on the basis of their relative fitness or capacity for a given job, they are invariably cheaper. Apply them to your own products and machines. See for yourself how they help to cut costs—and, consequently, to increase sales through the better and more uniformly dependable products they help to turn out.

Our helpful technical books, "Molybdenum in Cast Iron" and "Molybdenum in Steel," cite most of the many applications in which Moly irons and steels excel — and which prove Moly as "industry's most modern and versatile alloying element." Copies of these books are yours for the asking—as is also the mailing of our periodical news-sheet, "The Moly Matrix." And, if interested in some particular alloy problem of your own, our laboratory facilities are at your command. Climax Molybdenum Company, 500 Fifth Avenue, New York.

CUTS COSTS MOLY SALES

of industry confronted by similar problems, in assembling and making available information on this subject.

Cooperation with public health agencies, insurance carriers, and the medical profession in forwarding health measures.

Assisting in standardization of dust-elimination equipment and improvement of shop operating conditions in the foundry industry through active educational work.

Promoting standards for dust-elimination and control equipment, in cooperation with agencies of the manufacturers of such equipment.

Giving encouragement by active means where enactment of equitable and fair compensation laws is sought in industrial states.

E. O. Jones for the past three years Consultant of Industrial Relations Bureau of the National Founders Association, has been made director of the safety and hygiene section, and will have his office at the headquarters of the American Foundrymen's Association, 222 West Adams Street, Chicago.

A plan has been arranged with the Saranac Laboratory of the Edward L. Trudeau Foundation for research and consulting service. Under this arrangement the services of D. E. Cummings, field director of the Saranac Laboratory, can be secured by individual foundries or groups of foundries, through the Safety and Hygiene section of A.F.A., for consultation or discussion of general policies dealing with medical and engineering control procedure designed to protect the health of foundry workers.

The Association is inviting the cooperation of all those interested in industrial safety and hygiene and advises that it has available for those who desire them, copies of a 30-page pamphlet reporting the session on "Good Housekeeping" of the 1933 Chicago convention. Also available for distribution are copies of a 64-page report of papers on "Dust Control and Employer Responsibility," presented at the 1935 convention held at Toronto, Canada.

Standards for Rotating Electrical Machinery

NEW and revised requirements for most of the rotating electrical machinery manufactured and used in the United States are now made available in a single volume, the American Standards for Rotating Electrical Machinery, just published by the American Standards Association.

Standard requirements and specifications for electrical machinery, from the large central-station generators and industrial and steel-mill motors to the small motors used on household appliances, such as vacuum cleaners and electric fans, are included in the new publication. Direct-current, synchronous, and induction machines, synchronous converters, and alternating- and direct-current fractional-horsepower motors are covered.

With new material added by the American Standards Association's Committee, the publication combines revisions of the material formerly published by the American Institute of Electrical Engineers in five separate pamphlets (A.I.E.E. 5, 7, 8, 9, 10) and those motor and generator standards of the National Electrical Manufacturers Association which are of general interest.

The National Electrical Manufacturers Association rules deal particularly with manufacturing practice as it has grown up for various types of machines and include such standards as values for rating purposes, dimensions, and structural details.

The outstanding accomplishment of the standards of the American Institute of Electrical Engineers has been the definition of the terms and conditions which characterize rating and performance. The line of demarcation has not been distinct, and with the growth and increased detail of both the A.I.E.E. and N.E.M.A. standards this dividing line became less distinct.

In the new standards, these two existing and overlapping sets of standards are combined to form one complete "common language" for rotating machinery.

Research Body Established for Modern Home

THE Kelvinator Corporation has announced that it has established and is maintaining The Temperature Research Foundation, with headquarters at 80 Broadway, New York, N. Y.

This foundation aims to advance standards of health, comfort, and leisure among American consumers in the fields of heating, food preparation and preservation, and air conditioning in home, office, and factory.

The foundation will operate under an advisory committee which includes Dr. Shirley W. Wynne, former Health Commissioner of New York City; Dr. Warren M. Persons, consulting economist and former professor of economics at Harvard University; Francis Keally, architect; Count Alexis de Sakhnoffsky, consultant designer; Lulu G. Graves, consultant in nutrition and organization of dietary departments; and Anne Pierce, consultant in home economics. Edward Heitman, who is chief engineer of the Kelvinator Corporation, will be the director of the foundation.

Occupational Index Announced

OCCUPATIONAL Index, a continuous monthly bibliographical listing of occupational information in current books, pamphlets, and periodicals, annotated and classified, has been announced by the National Occupational Conference, 551 Fifth Ave., New York, N. Y. The average monthly issue contains between 50 and 100 references to information on anywhere from 25 to 75 different occupations. In addition to some 75 educational journals, the list of magazines from which references are selected includes as many general and technical as general periodicals. MECHANICAL ENGINEERING is on the list.

Insurance Rates and the New Diesel "Standard Practices"

NEW coverage and rates for insurance on Diesel engines, in many cases representing substantial reductions from rates previously in effect, have been announced by the Boiler and Machinery Department of the National Bureau of Casualty and Surety Underwriters, effective May 1, 1936. Promulgation of the new rules follows closely the adoption by the Diesel Engine Manufacturers' Association of changes in their "Standard Practices," and has resulted from a series of conferences between committees of the two organizations. These changes, both as to insurance rules and as to the manufacturers' standards, are regarded as the most important of the many forward steps which have characterized the rapid development of the Diesel engine in this country during recent years.

In the new "Standard Practices," the manufacturers lay great stress on the advisability of installing closed cooling systems, since it has been found that many troubles—namely, cracked cylinder heads, cracked pistons, stuck pistons, and other difficulties of like nature—have been due to improper cooling conditions. The use of the open cooling system, in which raw water circulates through the engine and goes directly over the cooling tower or through the spray pond, is usually the cause of such accidents. Experience has shown that even though the make-up water in an open system goes through a softening process, this practice does not eliminate all breakdowns.

Bibliography on Marketing Research Available

TO meet the need for an analysis of the literature on marketing research, The American Society of Mechanical Engineers has issued a selective bibliography on the subject. Prepared by George W. Kelsey of the A.S.M.E. Management Division, this publication presents approximately 90 titles dealing with the many and diverse aspects of the marketing research technique, its limitations at the present stage of development, and the necessary qualifications of those who are employed to plan, organize, or execute such projects. Each reference summarizes the content of the article or book indexed. The bibliography may be obtained from the A.S.M.E. Publication-Sales Department at a price of $1 a copy.

Coal-Utilization Course at Illinois

THE third University of Illinois "short course" on coal utilization will be held on the campus, Urbana, Ill., June 9, 10, and 11. The purpose of the conference is to present technical and practical information pertaining to coal and its efficient utilization for the benefit of those engaged in mining,

(Continued on page 408)

LAYER-ON-LAYER
CONSTRUCTION
means
STRENGTH
and
DURABILITY

LUBRICATION
in each
SINGLE STRAND
means
LONG LIFE
and
PREVENTS
FRICTION

BOTH THESE ESSENTIAL QUALITIES
ARE COMBINED IN

"PALMETTO" PACKING

It is the most economical packing on the market, because it lasts so long.

Long life in service, with less wear on rod or shaft, is the only method to determine the true cost.

"PALMETTO" has no equal for High-Pressure, Super-Heated Steam and Compressed Air, as it is made of the longest asbestos fibre obtainable.

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Also send for ABC Chart
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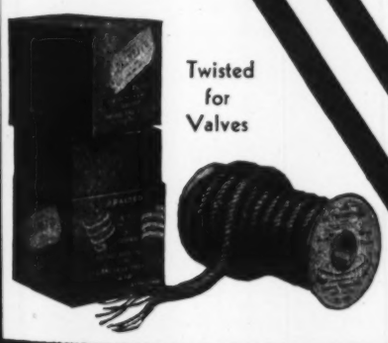
Many valves can be packed from one spool by unstranding



Twisted for Valves

Avoid Rod-Friction
—
It's Expensive

Braided for Rods